POWER

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Interest

SOME weeks ago I received a letter deploring the fact that there seemed to be fewer men who worked because they liked to, who had the old spirit of craftsmanship, who found in their work and the realization of its results all of the interest of a game or a sporting contest.

And one week I made the theme of one of these forewords, "Interest and Application."

And then I received several letters from men who claim they have had that kind of interest in their work all of their lives but have never been able to cash in on it.

One, a technical graduate with a knowledge of French and German and a dozen years of experience in power plants, grieves because upholsterers are getting over $50 a week. A man with that outfit and experience ought to be commencing where the upholsterer leaves off.

The majority of them seem to have it in for their employers because they have got no higher and to regret and begrudge the interest that they have taken in their work. They look upon it as an unrecognized and unrequited service to another instead of as the principal element in their upbuilding of themselves.

And then there comes the broad question—What is the use of building themselves up anyway if they cannot get more money for it than somebody else can get for stuffing mattresses?

There are, broadly, two classes of men who work in power plants, and one of the classes tells the other what to do.

It is the class that is contented to take orders rather than to assume responsibility that has to compete with upholsterers and other hand laborers in the matter of wages. There is a good supply of them, men who can do a few simple things under somebody else's direction, and their wages will naturally not be higher than those paid to men in other departments doing comparable work.

The fellow who gets the money is the fellow who has the knack of getting things done, the man that the owner can lean down upon hard and know that he will keep things going, the man who seeks responsibility and gets results.

The interest and application that I wrote of are not all that is necessary to get a man up into the executive class.

No man will get to be chief without such interest and application, but not every interested, faithful worker around a power plant will get to be chief.

The regrettable case is that of the man who has all the qualities that would make a successful chief if somebody would grab him out of the limited sphere where he has been building himself up and put him into the bigger place that he could fill, but who has not the initiative, the venturesomeness, the front and self-confidence to force himself into the line of promotion. There were probably other as profound lawyers as he in the time of Daniel Webster, but nobody hears of them.

And it is deplorable that front and self-assertion often win out over greater and retiring merit.

Nevertheless, I believe that I am sound in urging interest and application not only as necessary elements of progress, but as putting a better and more attractive complexion upon the day's work.

F. R. Low

Powdered Coal Used Exclusively in this Industrial Plant

By F. K. NORTH
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OUR interest in the burning of powdered coal was centered in an endeavor to assist the health department of Chicago to keep the city clean by the elimination of smoke and to provide an economical means for transportation of coal from car to furnaces. Its adoption has resulted in the elimination of smoke at a considerable saving over previous operation. From an economical viewpoint it was necessary to provide other means for the transportation of coal than the wheelbarrow, and this was found in the compressed-air transport system using air as a conveyor for the coal after it had been reduced to powdered form. The company had long been contemplating the erection of a central power house with boilers that could be tied in with the waste-heat boilers, making it possible to use the latter for the purpose for which they were intended, as the saving derived from them when melting iron was more than lost owing to the uneconomical features of the auxiliary firing between heats.

One Style of Burner Adopted for All Furnaces and Ovens

Because of the various styles of furnaces to be equipped for powdered coal, it was deemed advisable to adopt a type of burner that could be standardized to meet the requirements for all furnaces and ovens.

In Fig. 2 is shown the general outline of one section of the works, giving the location and approximate distances from the pulverizing plant to the different furnaces. The dotted line represents the 4-in. pipe line through which coal is transported from the pulverizing plant to the furnaces, changes in direction being made by switching valves. Through this 4-in. line it is possible to deliver to any furnace bin one ton of coal in less than one minute by using an air pressure of 50 pounds. A section through the pulverizing building is shown in Fig. 3. The coal is delivered from bottom-dump cars into track hoppers which discharge onto a belt conveyor running over a magnetic pulley to remove the tramp iron. Directly under the magnetic pulley is a single-roll crusher through which the coal passes to a bucket elevator which discharges it to a screw conveyor supplying two 30-ton bins. At the discharge end of these bins are variable-speed feeders discharging into rotary driers in which the moisture in the crushed coal is reduced from 6 to 10 per cent to somewhat less than 1 per cent.

The driers automatically discharge dried coal into a second elevator delivering by chute into the dried-coal bin. From here the coal is fed into pulverizing mills by an adjustable feeder, where it is ground so that 85 per cent will pass through a 200-mesh screen. The pulverized fuel is drawn up into cyclone separators by an exhaust fan, from which it drops into the storage bin and the air returns to the pulverizer. From storage the coal drops by gravity to the "shooting" tank, from which it is transported to the furnace bins by compressed air at 50 lb. pressure. The "shooting" tank is supported on scales which automatically weigh the amount of coal delivered to each furnace.

Moisture Is Reduced to Less Than 1 Per Cent In Rotary Driers

From the drier furnace the hot gases of combustion are drawn through the drier and delivered to a cyclone in which the fine particles of coal picked up by the gases are separated and used as fuel in the drier furnace. This method was adopted, as it prevents carrying over into storage the light foreign matter in run-of-mine coal and also provides an economical means of firing the drier furnaces.

With an additional pulverizer now being installed,

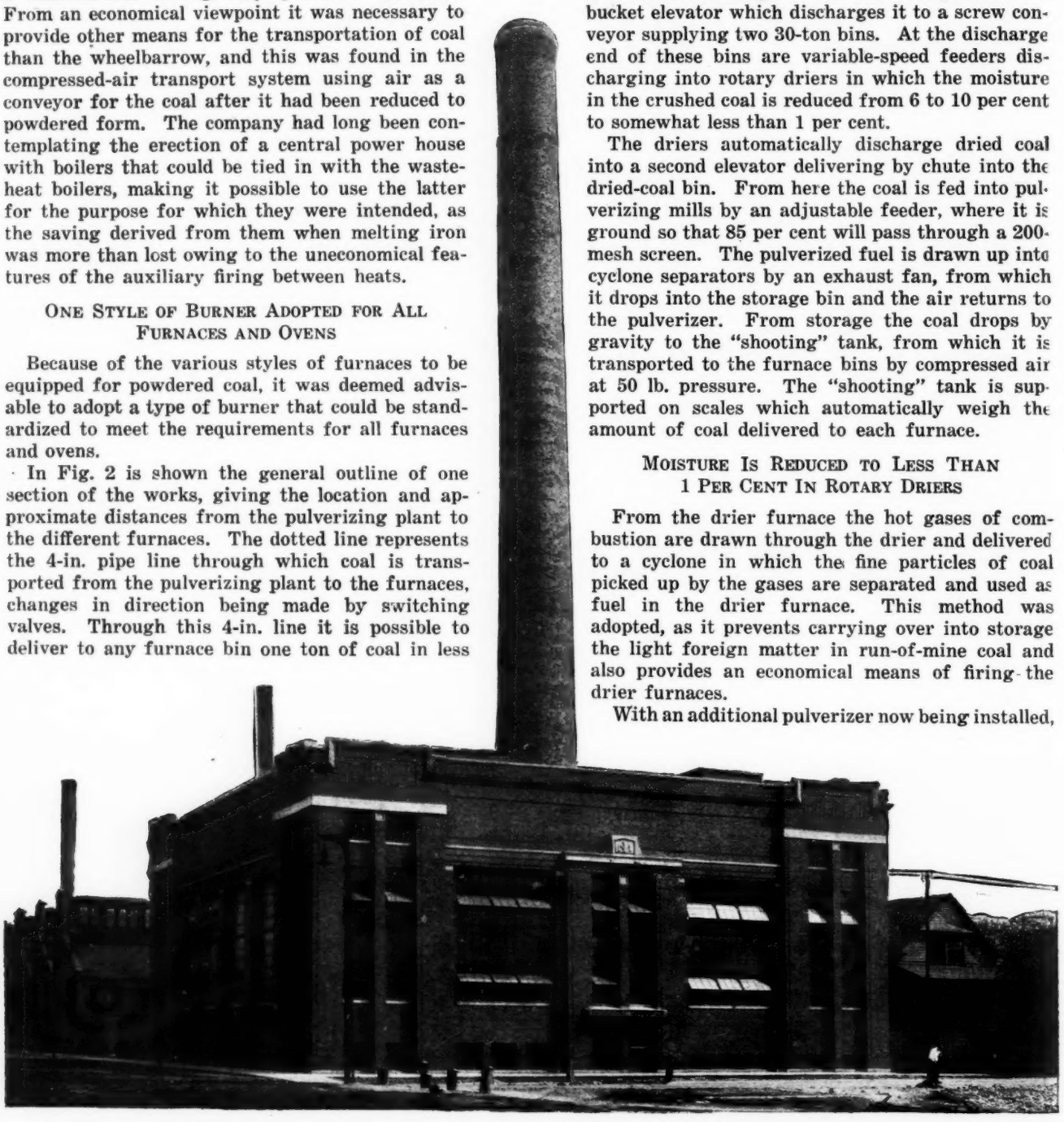


FIG. 1—EXTERIOR VIEW OF POWER PLANT OF THE ILLINOIS MALLEABLE IRON COMPANY, CHICAGO

the plant has an hourly capacity to pulverize about 9 tons of coal. It is operated by two men who take care of all operations from the track hopper to the furnace bins. The driving motors aggregate 160 hp. Exclusive of the building the initial cost of this equipment in-

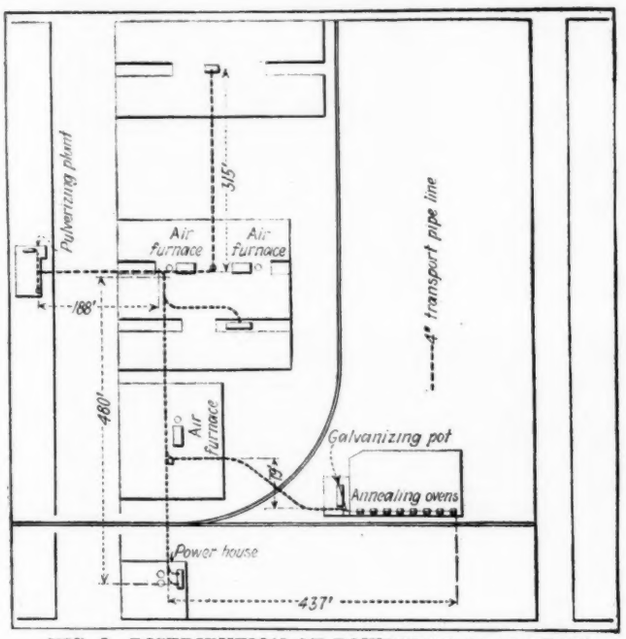


FIG. 2—DISTRIBUTION OF POWDERED COAL FROM CENTRAL PULVERIZING PLANT

stalled was about $50,000. The building is approximately 78x38 ft. in plan and 38 ft. high, with all storage bins, runways and collectors hung from the roof girders.

Fig. 1 is an exterior view of the power house. At the time this picture was taken, two 3,000-sq.ft. vertical water-tube boilers were operating at approximately 125 per cent of rating. At this rating practically no smoke or ash is discharged from the stack. All the ash that does not settle in the combustion chamber is deposited at the foot of the stack and is removed periodically.

Fig. 4 shows the top of the burners located in the arch of the furnace; also the feeder pipes from the 20-ton storage bin that is hung from the roof girders of the boiler room. These bins are provided with manholes at the top for cleaning purposes and also a gage for determining the amount of coal in the bin. This gage is operated from the boiler-room floor. At the under side of the bin is a dust-tight gate by means of which the coal supply can be shut off entirely should it be necessary to make repairs to the burning equipment. This equipment consists of two 2¾-in. feed screws running in standard 3-in. pipes and driven by a 1½-hp. constant-speed motor. The speed variation is obtained by means of a variable-speed transmission so arranged that the screws operate at from 25 to 100 r.p.m., delivering a sufficient amount of coal to run the boilers up to 150 per cent of rating. The boiler ends of the screws terminate in a T-shaped casting connected to the burner.

Design of Burner Permits Use of Low Air Pressure

The burner, a section of which is shown in Fig. 9, operates as follows: The coal drops through a fall pipe by gravity into the coal inlet opening, an adjustable scoop being set so as to distribute the coal uniformly around the inner pipe of the burner. The air entering the burner at a pressure corresponding to from 0.5 to 1 in. of water, is divided into two flows by means of the inner pipe, the outside flow carrying the coal, the inside flow forming a core of combustion air. The volumes of air are so proportioned that taking a section through the burner nozzle, the outside ring of coal and air does not form a combustible mixture. This explains why it is possible to use such a low air pressure without danger of combustion or backfiring in the burner itself.

The coal and air enter the combustion chamber in large volume and at low velocity. The air in the center of the mixture expands rapidly, causing a still more intimate mixture between the coal and the air, so that early and complete combustion takes place. Using low-pressure air means combustion nearer to the burner, making it possible to maintain a distance from the under side of the flame to the bottom of the combustion chamber so great that the heat radiated will not melt the ash, but allows it to collect in powdered form in the bottom of the furnace. For successful operation this is of vital importance.

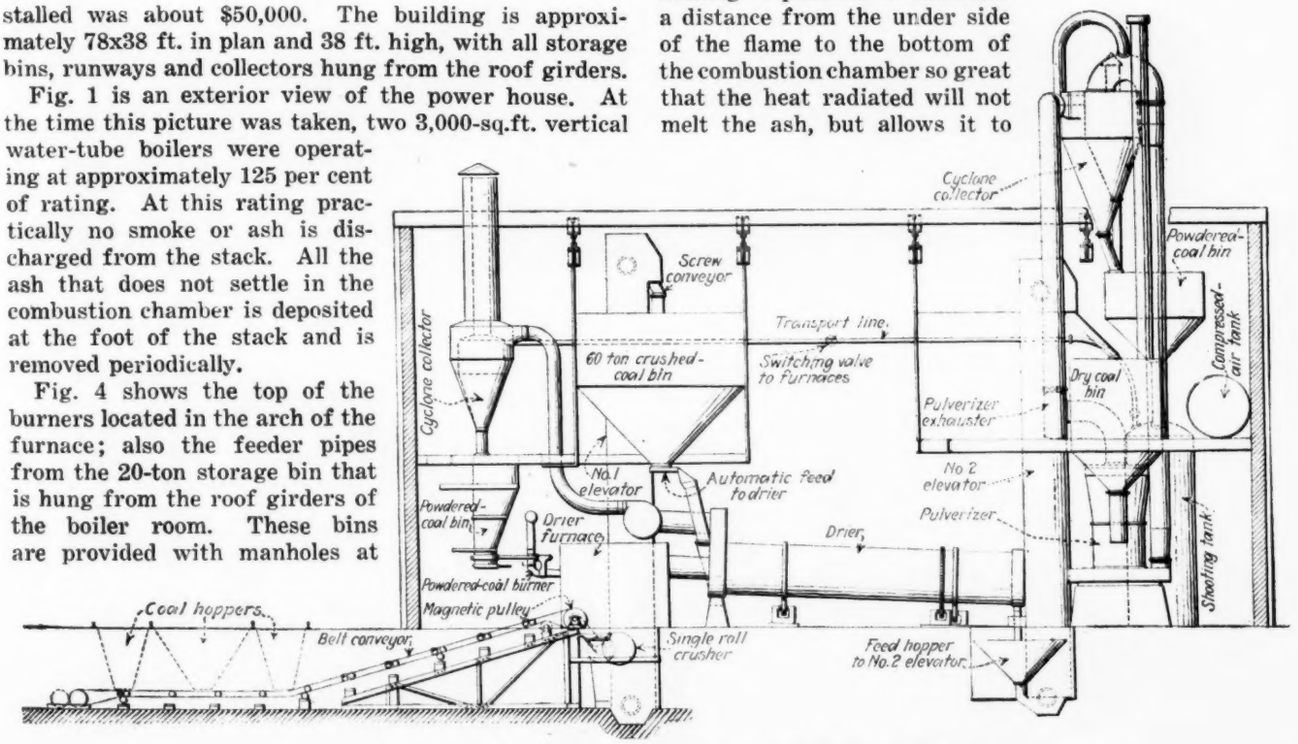
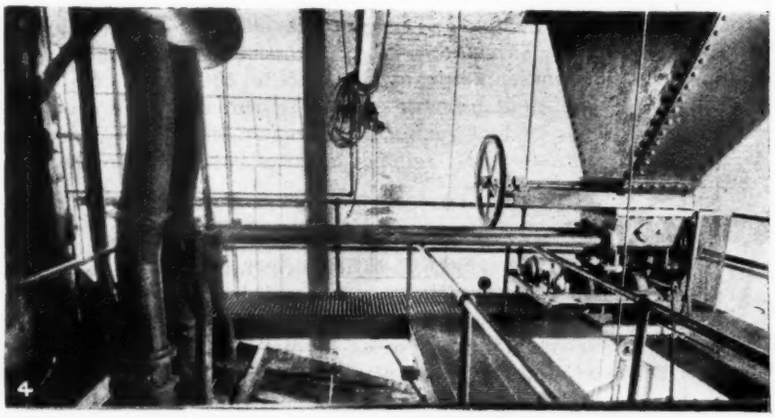
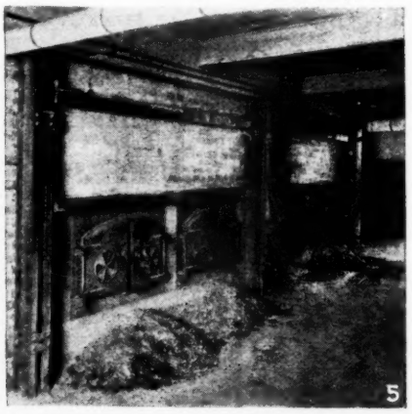
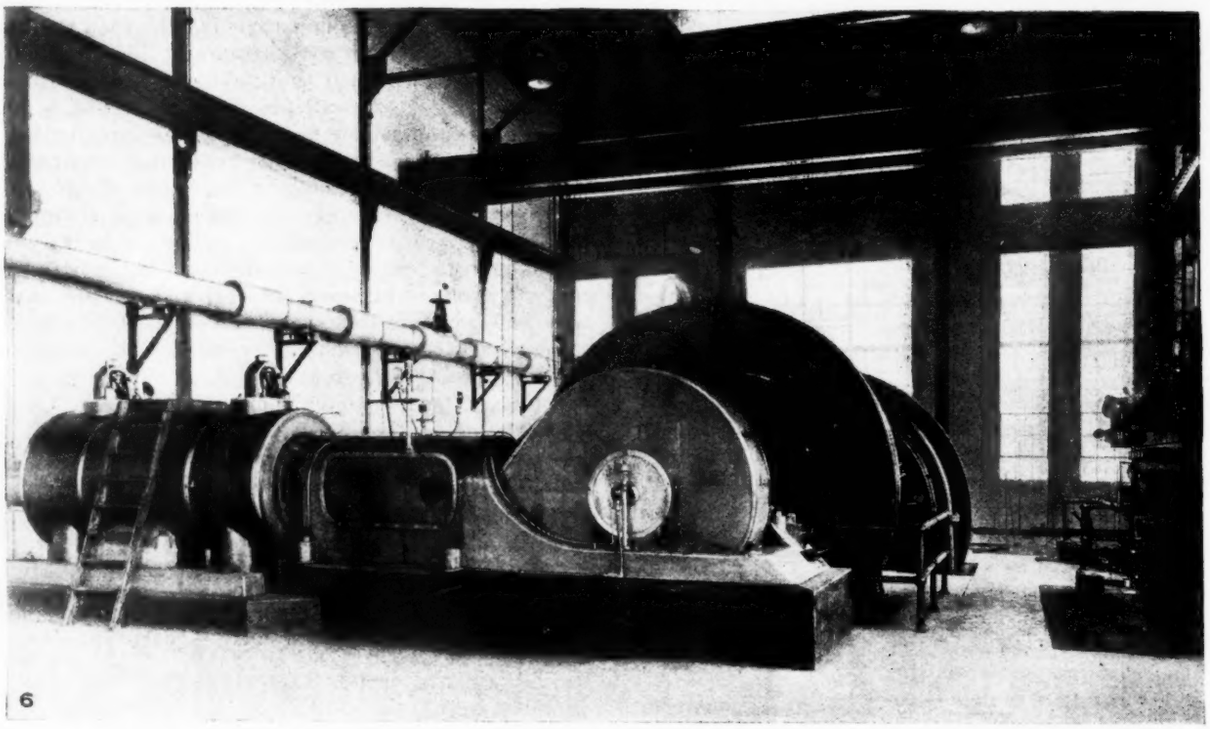


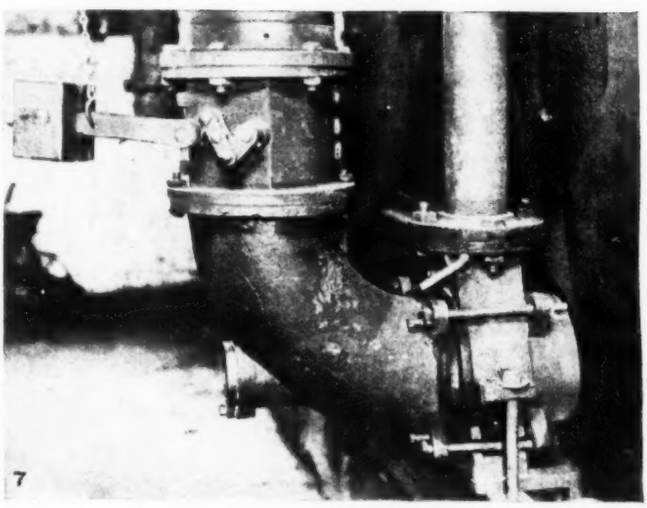
FIG. 3—SECTION THROUGH COAL-PREPARATION PLANT

The double butterfly counterweighted valve used to regulate the quantity of air to each burner is shown in Fig. 7. This particular burner supplies the drier furnace, but the same type of air valve is used throughout.









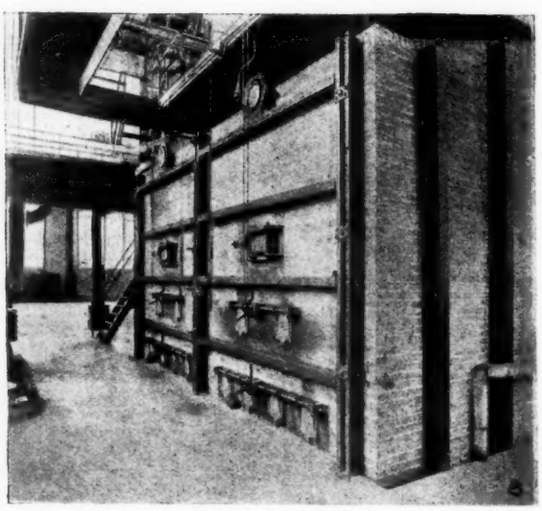


FIG. 4—TOP VIEW OF FURNACE, SHOWING POWDERED-COAL BURNERS AND SCREW FEEDERS. FIG. 5—ASH FLOOR IN BASEMENT. FIG. 6—ONE OF THE GENERATING UNITS—AN 850-KW. GENERATOR DIRECT-CONNECTED TO UNAFLOW ENGINE. FIG. 7—TYPE OF AIR VALVE USED. FIG. 8—FRONT VIEW OF FURNACE ON MAIN BOILER-ROOM FLOOR

In the boiler installation it is attached to the variable-speed transmission in such a way that the quantity of air supplied is varied in proportion to the coal.

The pressure of the air corresponds to 1 in. of water, and about 50 per cent of the theoretical amount required for combustion is supplied through the burner. The rest of the air for combustion enters through the regulating doors located on the furnace front and also through the ash doors. Air is supplied to the boiler burners by a combination blower and exhauster which takes the air from a space under the boiler furnace floor in order to keep it cool and also to preheat the combustion air.

Secondary Air Is Drawn Through Passages in Furnace Walls by Stack Draft

In the upper portion of the boiler front shown in Fig. 8, the large doors are used for lighting the fire by means of oily waste attached to a bar and held under the incoming coal, which immediately ignites. The lower doors are used for supplying additional air for combustion. Fig. 5 shows the lower portion of the boiler front located in the basement. The four open doors between the furnaces connect with flues in the furnace walls, the air being drawn into these openings by the stack draft, circulating through the setting walls and entering the combustion chamber opposite the lower doors shown in Fig. 8. This arrangement preheats additional air for combustion and also helps to keep the setting cool. The ash shown on the basement floor is in powdered form with practically no slag formation. It represents a 24-hour run.

A section through the boiler furnace giving a good idea of the size and the location of the air ducts, is

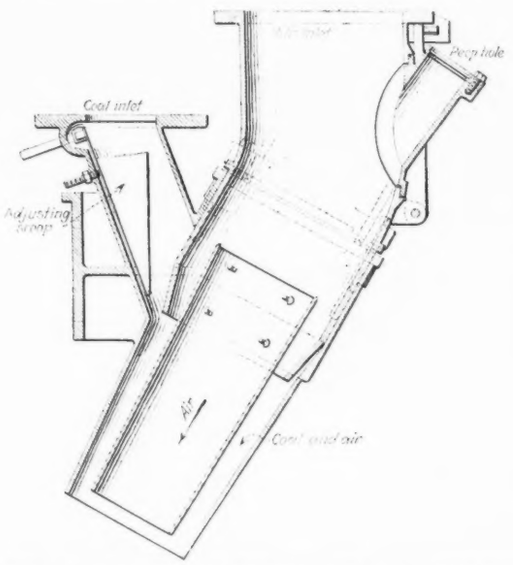


FIG. 9—SECTION OF POWDERED-COAL BURNER

shown in Fig. 10. The drawing also shows an attempt at ventilating the upper and lower surfaces of the arch, which we have found essential in the burning of powdered coal. The combustion space reduces to about 0.66 cu.ft. per pound of coal burned per hour.

During more than six months of operation with these boilers we have found no destructive effect upon the tubes from excessive heat, but from our experience do expect some slight troubles with the furnace lining until such time as brick suitable for such extreme temperatures can be found. At the present time we are unable to give exactly the actual saving by the use of powdered coal, but can safely say it is paying a substantial return on the investment and that results obtained from the boilers and annealing ovens warrant the equipping of all the air furnaces, core ovens and galvanizing-pot fur-

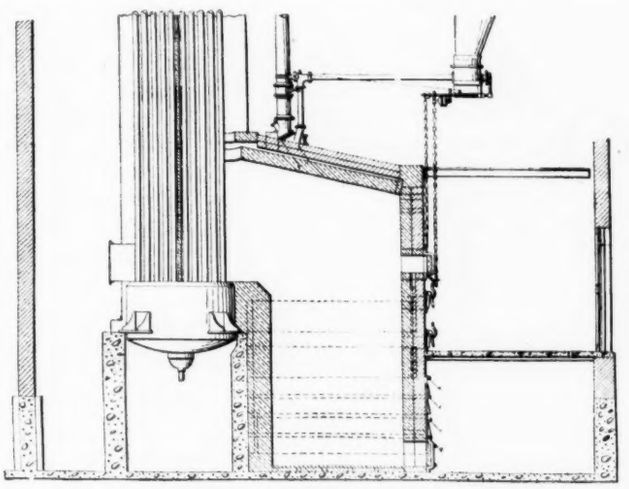


FIG. 10—SECTIONAL ELEVATION THROUGH BOILER FURNACE

nace to burn this fuel. To adapt properly a powdered-coal system to our plant with a view to standardizing the equipment, we considered it advisable to do our own engineering and erection work.

Elements and Compounds

An element is a substance that has only one kind of atom. There are about eighty known elements, but only a few need be considered here. Pure carbon, which is approximated in nature by diamonds and by charcoal, is an element. No matter how far we subdivide it, it still has the same properties; it is still carbon. The same is true of the gas oxygen.

Now if oxygen and carbon are combined in certain proportions (by burning the carbon), we get carbon dioxide (CO_2). The symbol CO_2 means that a single molecule of carbon dioxide contains one atom of carbon (C) and two of oxygen (O). They are hooked together by some invisible bond that is probably electrical in nature. If you take a given amount of carbon dioxide and divide it into smaller and smaller portions, it will still be carbon dioxide until you have but one molecule left. But the molecule is the smallest division of a compound. If you split up the molecule of carbon dioxide you have left two atoms of oxygen and one of carbon, both substances totally unlike the carbon dioxide of which they were constituents. In fact, it is generally true that a compound bears no resemblance to the elements of which it is made. An example is common table salt, which is a combination of the rare and expensive metal sodium and the poisonous gas chlorine.

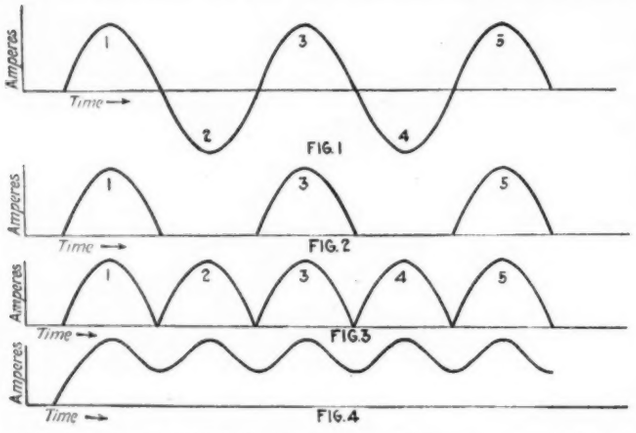
In Germany the scarcity of oil has made it worth while to extract the low-temperature tar from coal before using it for power or heating purposes. By Bruno Meyer the distilling and burning processes have been combined in a new type of grate furnace serving the boiler.

Conversion of Electrical Power

Practical Methods by Which Alternating Current May Be Changed to Direct Current or Vice Versa for Commercial Purposes—Mercury Vapor Rectifiers, Motor-Generator Sets and Synchronous Converters —Uses and Limitations of Each Method

BY J. ELLIOT CANNELL*

ONLY three types of apparatus, in medium- and large-sized equipment, for converting alternating current to direct current or vice versa are now in general use—the mercury-arc rectifier, the motor-generator set and the synchronous converter. The arc rectifier is only capable of converting alternating



FIGS. 1 TO 4—ALTERNATING CURRENT AND THE FORMS IT TAKES WHEN RECTIFIED IN A MERCURY-VAPOR RECTIFIER

to direct current. Each of these types is limited in its application, and a study of the characteristics of each should be made before deciding upon any one means of conversion.

MERCURY-ARC RECTIFIERS

The chief applications in this country of the mercury-arc rectifier are for charging storage batteries and for operating lamps on series arc-light circuits; in Europe they have been applied commercially to industrial and railway loads. The rectifier consists principally of a glass bulb containing ionized mercury vapor at low pressure (the air having been exhausted), having one electrode of mercury and two or more electrodes of some other conductor, such as iron. A high resistance is offered to a current flowing from the mercury to the iron electrodes, but a low resistance is obtained for a current flowing in the opposite direction. The current flow through the mercury vapor is started by forming an arc in the tube between the mercury electrode and an auxiliary starting electrode, by tilting the tube, Fig. 5.

If only one iron electrode were used, the current between the iron and mercury electrodes would have such a wave form as in Fig. 2, one-half of the alternating-current wave, Fig. 1, being suppressed, since the current flows in only one direction. But if two iron electrodes be used, every alternation of the current will be rectified, and the wave form will be as in Fig. 3.

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If the current between the electrodes drops to a zero value, as is the case in Figs. 2 and 3, the mercury vapor loses its ionization and the tube will have to be started over again. To avoid this, an inductance is inserted in the tube circuit, and the current wave then takes the form of Fig. 4, being a varying direct current. For the successful operation of a rectifier, an auto-transformer, two inductances and a resistance are also needed, as shown in Fig. 5.

The efficiency of the mercury-arc rectifier is practically constant at all loads, but varies with the voltage, being high at high voltages, ranging anywhere from about 94 per cent down and operates at a power factor as high as 98 per cent in the large steel-clad types. The useful life of the tube is generally from 400 to 1,000 hours, and tube renewals cost from 5 per cent to 10 per cent of the first cost of the outfit.

MOTOR-GENERATOR SETS

Motor-generator sets are made to convert alternating current to direct current or vice versa, also to transform direct-current power of one voltage to direct-current power of another voltage and to change

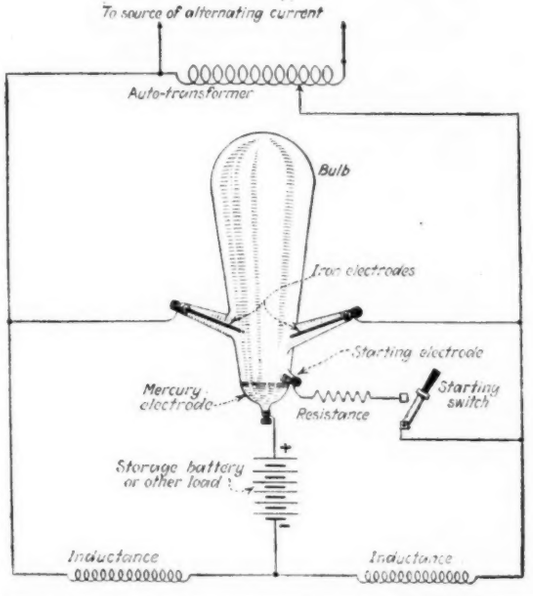


FIG. 5—DIAGRAM OF MERCURY-VAPOR RECTIFIER

alternating current of one frequency and voltage to alternating-current power of another frequency and voltage.

Motor generators are used to convert alternating current commercially where a wide variation in direct-current voltage is necessary or where it is desirable to have the alternating-current and direct-current sides independent. When so used, the motor generator usu-

ally consists of an alternating-current motor of either the synchronous or the induction type directly connected to a direct-current generator. The synchronous-motor drive is more generally used because of its higher efficiency and the fact that it can be made to take a

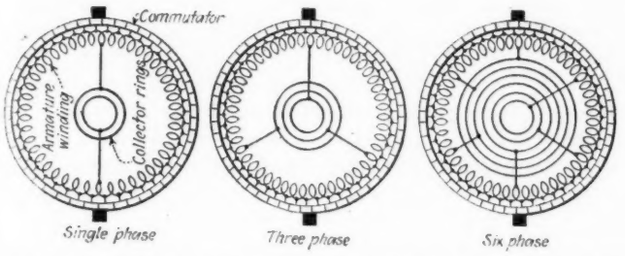


FIG. 6—DIAGRAM OF A SINGLE-PHASE, A THREE-PHASE AND A SIX-PHASE ROTARY CONVERTER

leading current, thus bettering the power-factor condition on the supply lines.

A motor generator is less efficient than the synchronous converter because of a double transformation of energy. The over-all efficiency of a motor-generator set is the product of the efficiencies of the motor and generator and ranges between 80 and 92 per cent.

Synchronous Converters

A synchronous converter resembles a direct-current generator and, from outward appearances, differs from the latter only in having slip rings at one end of its armature and a commutator at the other end. By supplying alternating-current power to the slip rings, direct-current power may be taken from the commutator or vice versa. When used to convert alternating current into direct current the converter is said to be direct, and when used to convert direct current into alternating current it is said to be inverted. When used inverted, the converter requires speed-limiting devices to protect it against excessive speeds caused by accidental weakening of the field strength. The converter is, however, generally used direct.

The armature winding of a converter is the same as a direct-current generator having taps from points equidistant on the windings connected to the slip rings. The number of taps is the same as the number of phases of the alternating current, on two-pole machines, except for single-phase current, which requires two taps.

Schematic connections are shown in Fig. 6 for a single-, three- and a six-phase rotary converter. A machine having an armature connected in this manner may be used as a direct-current generator or motor, as an alternating-current generator or synchronous motor, as a direct or inverted converter, and as an alternating-current and direct-current generator simultaneously by having its armature driven mechanically. Any direct-current generator provided with suitable taps would theoretically act as a converter, but its design and proportions might make its operation unsatisfactory.

Methods of Starting Rotary Converters

Converters may be started in one of three ways—from either alternating-current or direct-current sides or by auxiliary mechanical power. Single-phase machines cannot be started from the alternating-current side, except when specially constructed.

To start a converter from the direct-current side requires a source of direct-current power, which is usually not available unless there are other converters in

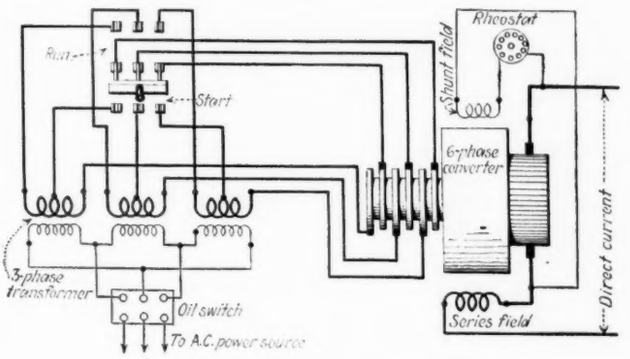


FIG. 7—SIMPLIFIED WIRING DIAGRAM OF ROTARY CONVERTER

operation in the same station. With this method of starting, the machine is brought up to speed by cutting out resistance in the armature circuit, and it is then synchronized with the alternating-current supply.

In starting by mechanical power, an induction motor is usually employed to bring the armature of the converter up to speed. The latter is then synchronized with the alternating-current supply. The induction motor should have one pair of poles less than the converter so that synchronous speed of the converter may be reached.

COMPARISON OF THE THREE COMMERCIAL METHODS OF CONVERSION

	Uses	Limits	Advantages	Disadvantages	Efficiency, Per Cent
Mercury-arc rectifier	Charging storage batteries and operating arc lights. Railway work.	50 amperes capacity with glass tubes, 200 to 900 amperes with steel-clad tubes, 7,000 volts direct current for series arc lights.	Small floor space.	High first cost. Limited to small and medium capacity. Tube renewals necessary. Not as reliable as converters or motor-generators. Rectified voltage and current pulsating. Will rectify a.c. to d.c. only.	From 98 down, depending on voltage.
Motor-generator sets.	Convert a.c. of any voltage to d.c. of any voltage and vice versa. Transforms d.c. of one voltage to d.c. of any other voltage. Change a.c. of one frequency to a.c. of another frequency or voltage.	Limited only in voltage and capacity as are motors and generators now on the market.	Independence of a.c. and d.c. power. Flexibility of control of d.c. power. Change in power factor does not change d.c. voltage. Transformers usually unnecessary. Power factor may be controlled if set is driven by synchronous motor.	Larger floor space. Lower efficiency.	80 to 92
Synchronous converter	Railway work particularly, although may be applied to other uses if electrical conditions warrant.	1,500 volt d.c. maximum. Made in capacity as large as 7,500 kw. No limit to a.c. voltage as transformers are necessary.	High-efficiency power factor may be controlled. Less floor space than motor-generators. Lower first cost than motor-generators. No change in d.c. voltage with change in frequency. Starter or compensator not necessary as transformer winding may be subdivided for this purpose.	Fixed voltage ratio. An auxiliary device needed for voltage regulation. Transformers always necessary. Starting characteristics poor. Field must be subdivided.	85 to 98

The most common method of starting a polyphase converter is by direct use of alternating power impressed on the alternating-current side, thus eliminating synchronizing. The alternating-current power can be reduced for starting purposes by using the mid-taps on the transformer secondaries. If this method of starting is to be used, a damping winding is built into the pole faces and the converter is started as an induction motor, the field being applied only after the armature is up to speed. A precaution necessary with this means of starting is to have the field subdivided into sections so that a dangerously high voltage will not be induced in it by transformer action, while coming up to speed.

Fig. 7 shows the connections for a six-phase converter, using diametral connections of the secondary leads. The reduced voltage for starting is obtained by mid-taps on the transformer secondaries. Reactances for voltage adjustment between the transformers and collector rings are not shown, as most manufacturers wind transformers for use with converters with sufficient inherent reactance to give the desired degree of compounding of the direct voltage.

Synchronous converters may be operated successfully in parallel by the use of equalizers as with direct-current compound generators. When operated in parallel, each converter should be fed from a separate group of transformers; or separate secondaries for each machine excited by a common primary may be used.

Reverse-current relays should be provided on the direct-current circuit breakers, and it is usually desirable to interconnect both alternating-current and direct-current circuit breakers so that in case one opens the other will also open.

Coal Storage in Plant of Moderate Size

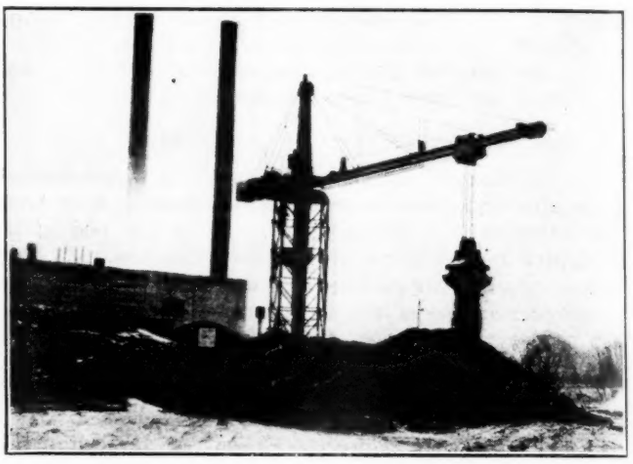
Storage of coal has become a problem to which every power plant in the country must give more attention than has been the custom in the past. The problem is more acute in plants of moderate size, where elaborate systems are not justified although it is essential that the coal be handled cheaply and stored as conveniently as in the larger stations.

As a typical example of what has been done in a relatively small plant, the simple and convenient installation of the Iowa City Light and Power Co. may be cited. This plant furnishes current to a population of approximately 15,000, much of the electrical energy being used for lighting purposes and only about 15 per cent for power. In addition to two waterwheel-driven generators having an aggregate capacity of 800 kva., the generating end of the plant has two turbo-generators, one rated at 1,000 kva. and another at 400 kva., as well as a Corliss engine-driven generator rated at 250 kva. Steam is supplied by four water-tube boilers, each of three containing 2,000 sq.ft. of heating surface and the other 4,400 sq.ft. of surface.

At this plant last winter an American Steel Storage Crane was installed to unload and store steam coal. The crane is of the type shown in the illustration, having a mast that turns inside a tower of lattice angle construction securely anchored to the ground. On the boom, extending horizontally from the mast, a trolley from which a 27-cu.ft. grab bucket is suspended, travels back and forth. The crane is operated by a 5½x8-in. engine with a crank-disk slewing attachment which operates the trolley and varies the radius of the buckets as well as slewing the crane. The engine is placed on the tail of the boom and is set back of the mast so that it acts as part of the counterweight. Steam is conducted to the engine by means of a swivel joint.

The crane has a rated capacity to handle a load of 3 tons with an effective radius of 50 ft. and the bucket may be moved outward or inward along the horizontal boom to any point desired within this distance. Thus around the tower the coal may be stored in a complete circle to a height approximating 24 feet.

At the plant in question some 2,500 to 3,000 tons of coal is maintained in the storage pile, this being about one-half of what could be stored around the crane if it were desirable to increase the storage. Shipments arrive only as required. Some days the crane unloads coal for ten hours straight, and at other times a week may pass without its being used. It has never been called upon to unload more than 200 tons of coal in eight hours, and approximately 1,000 tons is unloaded in a month's time. Without being extended, the crane unloads a car of 50 tons in an hour and a half and is reported to do a good job of cleaning up with one laborer in the car.



CRANE AT WORK AT PLANT OF IOWA CITY LIGHT AND POWER COMPANY

Besides unloading coal, it is used to load the ash and cinders into railway cars, and could if the plant were designed for such an arrangement, be used for transferring the coal from the stockpile to overhead bunkers or unloading directly from car to bunker.

Based on an initial investment of $11,500 for the entire equipment installed, the ton cost of handling the coal has been computed by the management of the Iowa City plant as follows:

	Cents Per Ton
Interest, 8 per cent	7.7
Depreciation, 6 per cent	5.7
Maintenance, 1.5 per cent	1.4
Labor	3.8
Total	18.6

The fixed charges were distributed over approximately 12,000 tons a year. The labor item includes the operator's time and the time of one man in the car for cleaning up. No accurate figures are available on the cost of the steam used. Attention is called to the fact that if the crane were kept busy, it might easily handle 60,000 tons of coal a year. This would reduce the fixed charges per ton to practically three cents, giving a total cost, minus the steam item, of 6.8c. per ton.

Easy Lessons in Engineering

Averages—Straight and Weighted

The "straight" average of several items is merely their sum divided by the number of items, and may be considered as the single number that most nearly approximates the size of all the separate items. Suppose that it is desired to get the average coal consumed per day for a week where the daily totals are as follows:

Day	Pounds
Sunday	18,253
Monday	44,791
Tuesday	39,262
Wednesday	33,411
Thursday	37,158
Friday	31,476
Saturday	21,596
	225,947 ÷ 7 = 32,278⅐

Here the average, 32,278 ⅐ lb., is obtained by totaling the column and dividing by 7, the number of items. The fraction at the right, while of no practical importance as a weight, is best retained until the checking is finished. As nothing but addition and division is involved, the answer can be checked as explained in the article "How To Avoid Mistakes in Arithmetic" in last week's *Power*.

It frequently happens that the items to be averaged differ but little from one another. This permits the use of a convenient short cut which may be applied either to the original averaging, to the checking or to both. For example, suppose that the second column of the following table shows the steam-pressure readings as taken every fifteen minutes during an engine test:

Number of Reading	Steam Pressure, Pounds Gage	Difference from 150
1	148	−2
2	151	+1
3	153	+3
4	152	+2
5	149	−1
6	149	−1
7	151	+1
8	152	+2
		+5

By inspection it is evident that the average lies between 148 and 153 and that it is in the neighborhood of 150 or 151. Taking 150 as a number easy to work with, enter in the third column the amount (plus or minus) by which each reading differs from 150 lb. To add these differences, read down from the top as follows: −2, −1, +2, +4, +3, +2, +3, +5. Next divide the total difference, + 5, by 8 to get the average difference, + ⅝. Then the average steam pressure must be 150 + ⅝ = 150.6. This convenient method of getting an average is best used in connection with the ordinary method, using one for the original computation and the other for the check.

In engineering and commercial work frequent reference is made to a "weighted" average in which certain items are considered as being more important than others and are therefore allowed to have more effect on the final answer. Suppose, for example, that it becomes necessary in an engine test to read the steam pressures at irregular intervals. It is then evident that a reading covering a long period is more important than one covering a short period and should have a proportionally greater influence on the final average. Such a set of readings is shown in the following table:

Time of Reading	Pressure, Pounds Gage
10:00 a.m	122
10:10	123
10:14	123
10:20	125
10:32	126
10:40	128
10:60	127

It should be fair to divide the time between any two successive readings into two equal parts and work on the basis that the first reading held constant for the first half of the period and the second reading for the second half. We may then make the following table:

Period	Weight = Number of Minutes in a Period	Pressure Reading	Weighted Pressure Reading
10:00 to 10:05	5	122	610
10:05 to 10:12	7	123	861
10:12 to 10:17	5	123	615
10:17 to 10:26	9	125	1,125
10:26 to 10:36	10	126	1,260
10:36 to 10:50	14	128	1,792
0:50 to 11:00	10	127	1,270
	60 = total of weights	874 = total of items	7,533 = weighted total

The method of weighting used requires some further explanation. We have decided that the average should be figured on the basis that the pressure remains constant at 122 lb. for the first 5 minutes, at 123 lb. for the next 7 minutes and so on. Then we might assume that a reading had been taken every minute throughout the test and set down in a column of sixty items, the first five of which were 122 lb., the next seven 123 lb. and so on. The total of this column divided by 60 (the number of items) would give the weighted average. Instead of writing down and totaling sixty items, it is easier to set down and total a fourth column in which the first item is 5 × 122 = 610, the second 7 × 123 = 861 and so on.

When 7,533 (the total of the last column) is divided by 60 (the total of the weights) the result is 125.55 (the weighted average). In this case the straight average is 124.86. With steam pressures around 125 lb. this difference is of no great practical importance.

As an example of a case where the straight average would give an entirely misleading result, suppose that it is desired to figure the average wage cost per man-hour for a repair job that required 40 man-hours of skilled work at $1 and 195 man-hours at $0.50. The straight average of $0.75 is far above the true average.

The following table shows the proper method of figuring the weighted average wage per man-hour.

Kind of Labor	Cost per Man-Hour	Total Man-Hours	Total Pay
Skilled	$1.00	40	$40.00
Unskilled	.50	195	97.50
Total		235	$137.50

Weighted average = $137.50 ÷ 235 = $0.585 per man-hour.

Development of the Solid-Injection Oil Engine

By H. F. SHEPHERD

MR. SHEPHERD, who was for several years chief engineer of the Bessemer Gas Engine Co., has had a broad experience in oil-engine design. His acquaintance with the solid-injection engine has not been confined to this country as he spent several months in investigating English practice. He will supply "Power" with several interesting oil-engine discussions during the current year.

FROM the original hot-bulb engines of Akroyd Stuart and Weiss oil engine progress has followed a devious path of elimination until the modern solid-injection engine combustion chamber is as simple as that of a gas engine. The early designs of hot-tube, bulb and labyrinth were succeeded by a simple combustion chamber of such form as to mass the air change before the spray. The hot surface was simplified in form. It developed that the hot surface must not be merely hot, but that it must possess a certain temperature. Means of hot-surface temperature control were developed, and just as we had learned all the requirements of "the hot surface," came the solid-injection oil engine developments of Guenther, Webb, McKechnie and Price. The hot surface, it seemed, was no longer required.

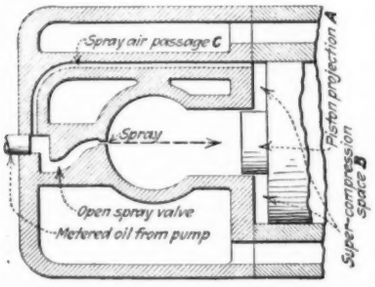


FIG. 1—HASELWANDER COMBUSTION CHAMBER

Following the appearance of these new-type engines many theories were advanced for their operation without the traditional hot-surface appendages of the oil engine. Just how far these were propounded by the inventor and just how far he connived at stating a plausible rather than an accurate case, I cannot say. The oil-engine trade has not yet arrived at a stage of maturity where inherent departures from the simple theory may be discussed with impunity. Steam-engine circles discuss matters of condensation, missing steam, wall action, etc., quite unblushingly, but we well know that oil-engine talk is still hedged by conventional theories and plausible properties.

Not through any special gift or insight but rather through some fortunate experience, I feel qualified to throw a little light on the relation that these engines bear to one another and to the older solid-injection engine of the hot-surface type. I do not propose to teach any inventor anything about his own brain child. I feel that he can agree with me and add volumes. I cannot condemn him for silence, but I do wish he wouldn't sweeten his texts. Reducing my suspicions to the following conclusions cost me a trip to England, the building of one special engine and a year of hard work.

First of all, without in any way defaming the solid-injection engine, it must be admitted that the atomization of a mechanical spray is never equal to that of an air spray. No matter how cloudlike the issue from an airless injector nozzle be, if the hand is held in its path the spray will coalesce instantly into liquid. Neither may the spray be diverted from its original direction by a solid object although an air blast will divert the spray. Solid interference of any sort produces complete condensation of the oil mist. In addition the spray may not always be as fine as it is possible to make it. There is no vehicle to furnish the energy to convey it through space as is the case with the air spray. Consequently, its particles most possess sufficient energy in themselves to overcome the air resistance and reach their allotment of oxygen. Above all, the mechanical spray is never sufficiently fine to stand instant ignition by contact with a red-hot surface. It must hang fire long enough to vaporize or smoky combustion will result. The early injection as compared to Diesel injection and the necessity to accept Otto or mixed-cycle combustion along with solid injection, is proof of this latter point, and to clinch the argument the old Franchetti engine with its air injection had a good exhaust even though the vaporizer often glowed. The properties of a mechanical spray may be enumerated as follows:

It may be suspended in space, but it cannot be deflected or checked by metal and retain its atomized form. It may, however, be successfully deflected by an air current.

It must be coarse enough to insure penetration, and what it lacks in the way of atomization must be accomplished by vaporization.

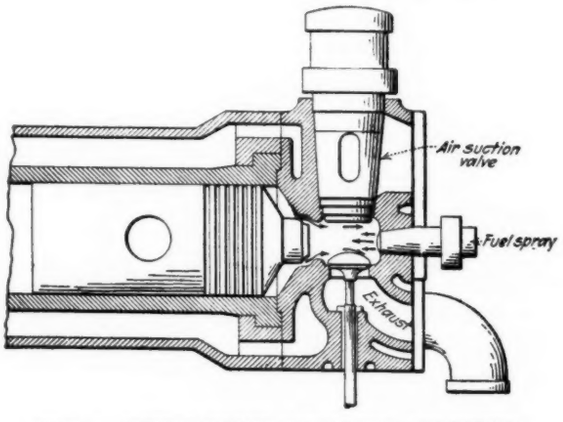


FIG. 2—DEUTZ SOLID-INJECTION CYLINDER

If their energy carries any oil particles through the air charge to the walls, they must not meet with excessive heat, which would crack the fuel and cause smoke.

As a separate and obvious conclusion the spray must not meet with a cold surface. Smoke will always result from such action.

About seventeen or eighteen years ago, Haselwander proposed to use a plug on the end of a piston so arranged as to enter a neck in the cylinder head near the

end of the stroke. The entrance of the plug into the neck divided the clearance volume into two parts, and the air in the cylinder clearance, being compressed at a higher rate, rapidly reached a pressure above that of the head clearance and was forced through passages provided into the head clearance, as shown in Fig. 1. The velocity set up was utilized to atomize and distribute the fuel. Haselwander proposed and patented many ways of applying this principle and built some engines which were not very successful. The trick of projecting a blast of air into the combustion chamber by restricting the opening with a plug on the piston was a clever one. A narrow orifice between cylinder and head would have produced the same blast effect, but its restriction upon suction, expansion and exhaust would have been fatal. The plug used by Haselwander entered the neck late in the stroke and was withdrawn early, thereby allowing the full area of communication to prevail. Almost everyone played with the idea in fancy or reality.

Jacob Guenther, another Deutz engineer, took up the idea and, after several misapplications, made a success of it along the lines of Fig. 2. Crossley and Webb followed with a somewhat different application; Fig. 3 shows the latter scheme as patented in the United States.

Development of Crossley Engine

The Crossley engine is the result of evolution from the original hot-bulb engine and exemplifies the history of almost all engines. As Mr. Webb told the tale to me, they had gradually increased the compression of their four-stroke-cycle hot-ball engines to 250 lb. The testers, he learned, had discovered that by turning the engine over on air for a number of turns it would gain sufficient heat from the repeated compressions to start without preheating. It may be safely left to the tester to discover every possible way of starting and stopping an engine. Following this a jacket was arranged over the hot ball, and it was learned that the engine could be operated without the hot ball (or strictly speaking with

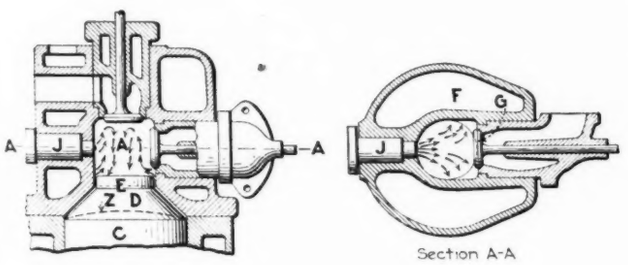


FIG. 3—CROSSLEY COMBUSTION CHAMBER

a "water-jacketed hot ball") after it was once set in operation.

Next to assign a reason for this. We know that adiabatic compression of air within the usual gas- or oil-engine cylinders results in pressures and temperatures such as may be calculated by using an exponent $n = 1.30$ to possibly 1.35. It is certain that this value of n is but a mean value, that conditions near the jacket wall approach isothermal or $n = 1$ and that the core of the volume may very nearly obey the adiabatic law with an exponent $n = 1.41$. Various forms were proposed for the combustion chamber, to insure the least disturbance of this "hot core" of the charge. These need not be described, as they were mostly passing fancies. The hot core does exist in most current designs, and from it ignition starts and flame is propagated. Its form and location may be altered by the geometrical form of the combustion chamber, or its temperature may be reduced by a central blast of air issuing from the cylinder into the combustion chamber through a narrow neck; but, generally speaking, the hot core in a modern combustion chamber of simplest geometrical form can hardly be avoided. Cold starting was the result of increased compression. Increased compression was made possible by improved injection systems, which, by better atomization, required less time for the vaporization of the oil. Tradition, dating from Mr. Diesel, said it could not be done. It had happened. Theories multiplied and inventors multiplied.

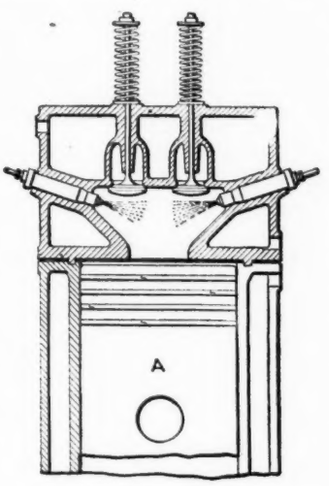


FIG. 4—PRICE SOLID-INJECTION CYLINDER HEAD

So much for cold starting. Combustion is another matter. Compression was raised to 300 lb. and the Haselwander displacer plug was adopted, to gain compression, I suspect. Certainly, the inventors had been on the fence about it before, as their patent records show. Immediate improvement is shown. Why? We have been told that the improvement is due to increased turbulence. The idea is indicated by the arrows in Fig. 3, and the specification of this patent application dwells upon this property of the construction.

The Turbulence Theory

Years ago English engineers charged vessels with gas-air mixtures fired with an electric spark and indicated the resulting pressures on a time base marked by the vibrations of a tuning fork. They learned, to their confounding, that the rate of combustion in the vessels was far slower than the engine rate of combustion. Then someone, I think it was Professor Callender, proposed to agitate the mixture in the vessels. He installed a propeller or fan in the head of the vessel and drove it through a stuffing box. An immediate increase in the rate of combustion followed, and it developed that turbulence in the actual engine cylinder follows as a natural result of the entry of the charge at high velocity through the valves and continues through compression. This degree of turbulence had always sufficed for gas engines. It is enough for the Price engine, Fig. 4, and enough for the Vickers, although we must admit the Diesel system with air injection does produce higher economy by reason of its greater turbulence and consequent better combustion. Had the Webb-Crossley design resulted in economies better than attained by Price or Vickers (compression considered), the theory that the turbulence set up by the displacer plug accounted for the working of the Crossley engine might be accepted.

The facts may be set down in the following order: First, a hot-surface engine is made to start from cold by increasing the compression; the hot surface is eliminated, but the engine smokes. Second, a displacer plug

is adopted and smoking ceases, even though the displacer plug had never shown any great merit as long as the hot surface was in use. It is certain that the displacer plug is necessary to the Crossley design. To find out what the results would be if there were no plug, I cut one off and the engine smoked badly.

My conclusion is this: It is impossible to adjust a spray that the oil will throw just so far to the fraction of an inch. Some of it is usually projected a little too far, as insufficient penetration is worse than a more energetic spray effect. The Price system causes the energies of two opposed sprays to meet the air entering the combustion chamber at an obtuse angle and checks further travel of the oil spray without contact with either hot or cold metal. It also introduces the element of distance which, if great enough, permits suspension. Vickers uses the piston head in checking the spray travel. In the Crossley engine with its transverse spray, any overtravel would cause the fuel to deposit on cold walls with fatal results to performance. Imagine, then, the moving screen of hot air entering from the cylinder and taking up any spray on its way to the walls, a silent invisible constantly flowing hot surface, the very essence and spirit of the hot surface.

It is true that the Crossley spray suspends as much of the charge as possible and the "hot-surface" deals with only a small part of the fuel. The same is true of any hot-surface engine of older vogue. However, let me be understood, the system works beautifully; its performance is equal to the records. I built a near-Crossley to find out and was more impressed than ever with the possibilities of the solid-injection engine.

Electric Power Rates to Refrigerating Plants

A year ago the president of the National Association of Ice Industries appointed a committee to prepare a paper on the stand-by charge to ice manufacturers using electric power. After a careful survey it was decided to take nineteen cities in the United States, to strike an average of the net cost per kilowatt-hour for power, the total stand-by charge for twelve months, total energy for twelve months, the per cent of stand-by to the total cost, the net cost per kilowatt-hour for stand-by charge, and the net cost per kilowatt-hour for energy charge.

It will be noted that the average kilowatt-hour of energy shows quite a difference. In some cases the power plants are part steam-driven and part water-driven, which of course makes a cheaper supply of power.

Concerning the table, which is reproduced from *Ice and Refrigeration*, Mr. Dunn, the chairman of the committee, stated that the data had been obtained from nineteen cities in which plants ran continuously for twelve months, and it was to be noted that the same number of kilowatt-hours was used in each city for the purpose of equality. The schedule showed that four cities have already seen what was coming, and that was the elimination of the stand-by charge or the ready-to-serve charge against the ice manufacturers. That means, however, that with the elimination of the stand-by charge, the ice manufacturer, to be fair, must pay an energy charge that will return the same total sum as did the former energy and stand-by charges. In many cases the stand-by charge does not appear to amount to very much. There was one objectionable feature to this plan, for where the stand-by charge is eliminated they have made a six months' contract, and the contract runs from May until October. The manufacturer is compelled to use 80 per cent of his power demand and to pay for 60 per cent of the 80 per cent during the winter months. For instance, if 600 hours were used in July, 80 per cent of that would be 480 hours, and whether it was used or not during those six months, 60 per cent of that would have to be paid. Concerning his own experience in Pittsburgh, he said they had the matter up with a representative of the power company, and at first they had a lot of contentions against its abolition, but after a dozen interviews their opinion changed, and they were willing to meet them more than half way. As a result, out of forty ice plants in Pittsburgh, twenty-five of them are connected with that company and the stand-by charge is eliminated.

In the discussion, Joseph McKinley, of the Duquesne Light Co., Pittsburgh, Pa., called attention to the fact that in 17 of the 19 cities compared, the rate schedule under which ice manufacturers are supplied electric service is that applicable to all industrial consumers. An analysis of these schedules shows that the cost per kilowatt-hour to any consumer varies with the load factor of his operation, or in other words, the greater number of hours per month he uses the capacity supplied by the power company the lower becomes his cost per kilowatt-hour.

This feature is typical and is embodied in practically all rate schedules effective throughout the country. It has the distinct and important advantage of equitably adjusting the price charged for service in accordance with the cost of supplying this service. The feature of rate schedule puts it right up to the consumer to adjust his operation to earn the best rate or cost per kilowatt-hour obtainable.

The ice-plant load maintains a high load factor operating practically continuously at constant load during the ice-making season and as a result obtains service at much lower cost per kilowatt-hour than other consumers using the same amount of energy.

Referring again to the tabulation, it will be found that in the other two cities included, the power companies offer a special rate to ice manufacturers somewhat lower than that available for other industrial users.

The justification for such special rate is based on the fact that the ice-plant load is supplied by the excess equipment installed to carry the annual peak load of the power company; thus very little or no power-plant investment is made for this character of load. Under this condition the fixed charges included in the power companies' cost of service are reduced and a reduction of rate made possible.

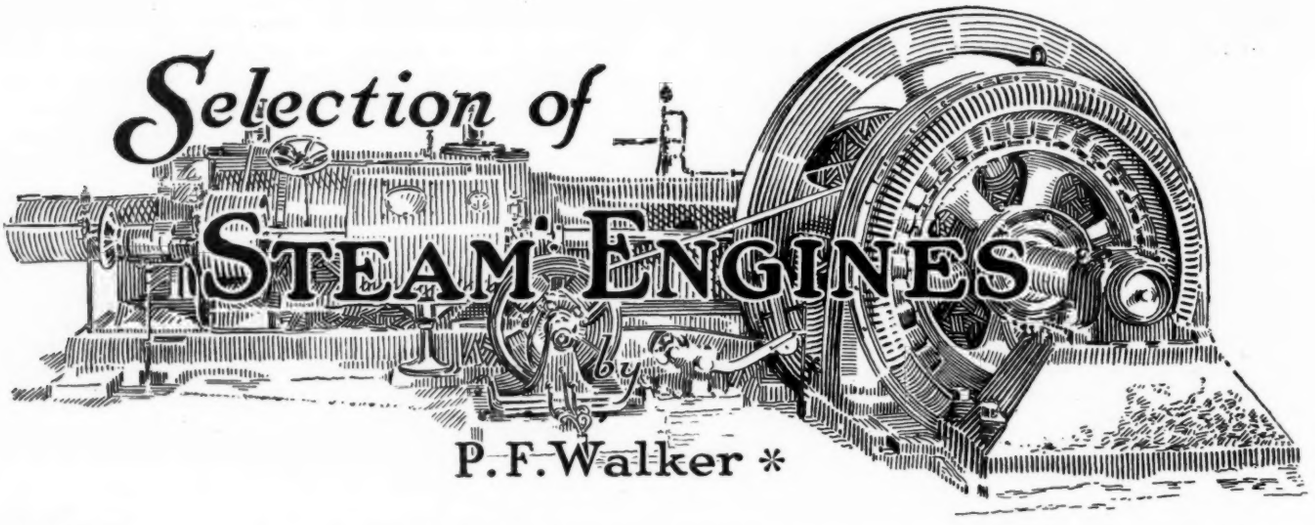
Where the power company's load is such that the ice-plant business adds to its annual peak load, such a concession in rate could not be made. In general, the effect of any given class of business on the power company's capacity required to serve is an important factor in rate-making. A company having a large residential lighting load and no power load finds that its capacity is determined by that required for the peak lighting load, existing probably two or three hours a day. For the rest of the 24 hours this capacity would be idle, so that if peak load could be taken so as not to increase this lighting peak, it could be supplied at a very low rate. If, however, the power company's system was prin-

cipally power load, the system capacity would be determined by this and much more weight given to the factor of investment cost in the power rate. The policy of practically all the larger companies has been that as their power load increased, giving utilization to the equipment throughout the day, to reduce residence rates to a lower figure. It has been this policy that has enabled our company to effect a reduction of approximately 60 per cent in domestic rates during the past 25 years.

TABLE I—POWER RATES

	Total Kw.-Hr. Consumption for 12 Months	Total Cost	Net Cost Mills Per Kw.-Hr.	Total Standby Charge for 12 Monthes	Total Energy Charge for 12 Months	Per Cent Standby Is of Total Cost	Net Cost Mills Per Kw.-Hr. of Standby	Net Cost Mills per Kw.-Hr Of Energy Charge.	Minimum Billing	Special Features of Contract
No. 1 Steam-Driven Power Plant	1,406,709	$16,242.06	11.5		$16,242.06			11.5	432 hours use of monthly demand in summer. 30 hours use of monthly demand in winter.	Summer months—April to September inclusive. Winter months—October to March inclusive. No stand-by charge. 60 hours use of monthly demand is primary energy. Remainder, secondary energy. 80 per cent of maximum demand created previous year is minimum in summer.
No. 2 Steam-Driven Power Plant	1,406,709	21,792.38	15.6	$9,312.00	12,660.38	42.4	6.6	9.0	Monthly stand-by charge	Highest demand created stands until exceeded. Rebate on interruptions specified in contract.
No. 3 Steam-Driven Power Plant	1,406,709	18,200.84	12.9	3,836.16	14,364.68	21.0	2.7	10.2	Monthly stand-by charge	75 per cent Power Factor required. Service measured on primary side. Straight power contract.
No. 4 Steam-Driven Power Plant	1,406,709	13,671.61	9.72	2,736.30	10,959.31	20.0	1.94	7.78	50 kw. Demand.	Metered on primary side. Off peak schedule. Coal rider. Figured without coal penalties.
No. 5 Part Steam-Driven Part Hydro-Electric	1,406,709	14,349.15	10.2		14,349.15			10.2	300 hp. $300.00	85 per cent power factor required at Power Company's option. Regular power contract.
No. 6 Steam-Driven Power Plant	1,406,709	14,037.98	10.0	3,038.75	10,999.23	21.6	2.16	7.84	300 kw.-hr. $375.00	Approximately 70 per cent annual load factor required. Coal rider. This data made without coal penalties.
No. 7 Steam-Driven Power Plant	1,406,709	18,125.26	12.9	3,992.00	14,133.26	22.0	2.8	10.1	$24.00 per kw. Annual maximum demand.	Discount for off peak service. Regular power contract.
No. 8 Part Steam-Driven Part Hydro-Electric	1,406,709	17,902.41	12.7	4,357.10	13,545.31	24.0	3.1	9.6	$250 less discount.	Customer supplies transformers. Measured on primary side. Coal rider. Minimum demand 150 kw.
No. 9 Steam-Driven Power Plant	1,406,709	16,457.75	11.7	4,821.00	11,636.75	29.0	3.4	8.3	Stand-by charge for 40 per cent connected load.	Off peak rider, special discount when customer furnishes transformers. Fuel clause. Power factor clause. Power measured on primary side.
No. 10 Steam-Driven Power Plant	1,406,709	23,919.39	17.0	2,764.64	21,154.75	11.6	1.9	15.1	No information furnished	Flat demand per hp. Flat rate for energy.
No. 11 Part Steam-Driven Part Hydro-Electric	1,406,709	18,435.15	13.1	7,560.00	10,875.15	41.0	5.37	7.73	Demand and equipment charge.	Fixed charge for equipment in addition to stand-by. Annual adjustment of stand-by. Stand-by charge refunded if no power used in peak hours in Winter.
No. 12 All Hydro-Electric	1,406,709	15,328.97	10.9		15,328.97			10.9	50 cents per month per hp.	Special discount for load factors up to 75 per cent, 20 per cent discount for off-peak 5 hours daily all year.
No. 13 Part Steam-Driven Part Hydro-Electric	1,406,709	11,603.23	8.25	2,604.00	8,999.23	22.5	1.85	6.4	50 per cent of maximum demand established during life of contract.	Off peak schedule. No service for from 1 hour to 2½ hours during Winter evening hours. 50 per cent of maximum demand for minimum stand-by charge.
No. 14 Steam-Driven Power Plant	1,406,709	20,405.34	14.5	3,705.56	16,699.78	18.0	2.63	11.87	40 kw. Deman.	Off peak discount if no power used except for lighting in Winter peak hours. Energy charge based on hours use of demand. Power factor clause. Primary measurement.
No. 15 Part Steam-Driven Part Hydro-Electric	1,406,709	20,096.34	14.29	4,154.99	15,941.35	26.0	2.95	11.34	10 kw. Demand.	Special rate for ice and refrigerating plants.
No. 16 Steam-Driven Power Plant	1,406,709	21,415.79	15.22	2,986.52	18,429.27	14.0	2.12	13.1	75 cents kw. of demand.	Power factor correction above 75 kw. demand. 24 hour interruption, portion of demand rebated.
No. 17 Part Steam-Driven Part Hydro-Electric	1,406,709	13,445.13	9.56	3,085.00	10,360.13	30.0	2.19	7.37	$1.00 per kw. of monthly contracted demand.	Demand set for six months.
No. 18 Gas and Oil Engine Driven Power Plant	1,406,709	19,299.77	13.72		19,299.77			13.72	$167.63	No details furnished.
No. 19 Steam-Driven Power Plant	1,406,709	14,451.59	10.27	2,219.75	12,231.84	15.0	1.57	8.7	$35.00	Off peak schedule for ice-making. Maximum demand not less than 200 kw during June, July, August and September. Guarantee 50 per cent monthly load factor.

KEY TO TABLE—No. 1. Duquesne Light Co., Pittsburgh, Pa. Steam. No. 2. Peninsular Electric Light Co., Detroit, Mich. Steam and Hydro. No. 3. Savannah Electric Co., Savannah, Ga. Steam. No. 4. Des Moines Electric Co., Des Moines, Iowa. Steam. No. 5. Puget Sound Water & Light Co., Seattle, Wash. Largely Hydro. 85 per cent. No. 6. Philadelphia Electric Co., Philadelphia, Pa. Steam. No. 7. Union Gas & Electric Co., Cincinnati, Ohio. Steam. No. 8. Union Electric Light & Power Co., St. Louis, Mo. Steam and Hydro. No. 9. New Orleans Ry. & Light Co., New Orleans, La. Steam. No. 10. San Antonio, Tex. Steam. No. 11. Birmingham Ry., Light & Power Co., Birmingham, Ala. Steam and Hydro. No. 12. Bureau of Power and Light, Los Angeles, Calif. Hydro. No. 13. Minneapolis General Electric Co., Minneapolis, Minn. Steam and Hydro. No. 14. The Toledo Edison Co., Toledo, Ohio. Steam. No. 15. Consumer's Power Co., Jackson, Mich. Steam and Hydro. No. 16. Cleveland Electric Illuminating Co., Cleveland, Ohio. Steam. No. 17. Georgia Ry. & Power Co., Atlanta, Ga. Steam and Hydro. No. 18. Sapulpa, Okla. Gas and Oil. No. 19. Commonwealth Edison Co., Chicago, Ill. Steam turbine plant.



Selection of Steam Engines

By P. F. Walker *

IN PAST years we have saved labor in this country because wages were high, and have been rather careless with power where coal has been cheap. But the day of cheap coal has passed. The price of that article is not going back to where it was before the war. We have a different problem to face. Power costs have increased, and that tendency must be checked, making the task of reducing costs doubly hard.

If the truth of these statements be conceded, it is clear that steam economy becomes a factor of increasing importance. It gives added meaning to the superpower project and other means for the utilization of water power. At the same time there are many industrial establishments for which the separate power plant is still the dominant factor, particularly where steam is demanded for building heating or for process purposes. These auxiliary needs are in many cases fully met by the exhaust steam of the most economical engines obtainable, which suggests the need for more accurate studies of such steam demands than are commonly accorded them. Many an engine is throwing steam into the atmosphere in unnecessarily large amounts for more than two-thirds of the working hours of the year, simply because no one has found out the exact extent of the demand. It is possible, also, to buy engines that will operate condensing and so save fuel during warm weather, and also operate with back pressure during periods of demand for heat.

Writing Engine Specifications

Good engineering in industrial power matters calls for a study of investments. This means a reversal of policies in many cases on the part of the management. Too frequently it has been assumed that any equipment that will run and carry the load is suitable. This is a vital matter in the selection of power units. Sound financing is the only way out. From the viewpoint of the national situation as regards industrial progress, capital in this country is plentiful and it must be used intelligently at every point. Only by utilizing this resource may we hope to win out in the contest for economic production.

It is assumed that something equivalent to competitive bidding will be the method of determining the price to be paid. Regardless of how these bids or proposals may be secured, some form of specification of conditions to be met must be prepared. No one can do this properly unless he knows just what he wants to accomplish and just what is on the market that will meet his needs.

Suppose the case is one where exhaust steam is called for in moderate amount for process purposes all the time and in larger amount for heating during five months of the year. Also, let it be one where individual units will not be over 500 kilowatts in capacity, the hours of service, excepting for occasional rush times, being not over ten hours a day. Let it be an electrically operated plant, so that the power units are engines direct-connected to alternators of moderate voltage. The only other steam-operated machines are the service pumps in the boiler room and one high-pressure pump for hydraulic press work, using in the aggregate no more steam than can be applied to good advantage in the feed-water heater.

Power and Heating Requirements

The fact should be appreciated that this is a set of conditions fairly representative of a host of establishments. Of all the coal mined and used in the United States, about 35 per cent is used in the industries. The steam railroads use nearly 30 per cent and the electric utilities only 8 per cent. The idea, which many people have, that power purchased from utility companies forms a large item among the industries, is erroneous. It is a fact worth noting, however, that the coal expended by the utility companies is used under the guidance of capable engineering talent in a degree far in the lead of that existing in the much greater undertaking represented by the combined industries. This means that opportunities for saving are much greater among the latter.

The first step in the initial designing of the plant is to determine and chart the demands for both heating and power. We will assume that this shows the demand for exhaust steam for process purposes, which is the year-round demand, to be less than the amount that the engines will use when the most economical type is considered. The extra amount needed during the five months of heating weather is not so readily adjusted. Common procedure among so-called heating men would consist in assuming an outside temperature of zero, or perhaps still lower in northern sections, estimating the steam required to maintain a proper temperature in the space to be heated, and then going on with the apparent

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assumption that this is a constant demand. As a matter of fact such weather conditions prevail for but a few weeks, or even days, in most of the country. In the more normal cool weather an hour or two in the morning measures the extent of the demand up to even a moderate estimate of steam requirements for an outside temperature of from 20 to 40 deg. Uniess a load curve with hourly variations is constructed, a great deal of overestimating in these lines is always indulged in, with the result that exhaust steam is sent uselessly into the atmosphere. The point is that it is not good practice to assume offhand that any form of engine will do. It will be better, under proper conditions, to use an economical engine and to bypass steam from the boilers via the reducing valve for a few hours a day for a few weeks to make up for deficiencies, rather than to waste steam for the other 90 or so per cent of the time. Give an intelligent man the data on a graphical chart, and he can find out whether good engines are worth while.

If it be decided that they are worth while, then we may go on with the design of plant characteristics on an economy basis. The type of engine must be selected before either the steam pressure or the number and capacity of power units can be fixed.

Different types can utilize high pressures with differing degrees of success. The unaflow engine, for example, is adapted to high pressures because its relative freedom from cylinder condensation losses makes a higher ratio of expansion possible. This type has been growing steadily in favor for installations that conform to the conditions that we have been assuming. For it a steam pressure of 175 lb. or even higher is appropriate, while engines of the counter-flow types, as usually constructed, will not carry so high a steam pressure to advantage.

IF you were called upon to advise as to the type and size of new power-plant equipment, would you throw up your hands in surrender as so many engineers have done? Read this discussion by Dr. P. F. Walker on the factors determining the kind of engine to install and so be ready to handle such a problem.

The characteristics of the economy curves for varying loads differ for different types. For some engines the steam economy continues to get better as the load increases to full rated capacity or even to overload conditions, while in others the point of best economy is reached earlier. It is clear that engine sizes should be selected so that units may operate near maximum economy conditions for as much of the time as is possible. This is where the power-demand curve must be studied. Two or more units are needed on the score of reliability, to avoid interruptions in service due to shutting down for repairs. Provision must be made for carrying the load with one unit down. Three units make a flexible combination, desirable if the load varies considerably. For more uniform conditions two units may meet all needs. If the peak load is far above the average and is maintained for several hours of the day, then, in a three-unit combination, equal sizes are desirable. If the peak does not run so high, then one unit should be smaller than the others so that when two are in service both may be loaded within the range of good economy. When variations are small, the regular unit may carry the maximum as overload. Studies of actual load curves are necessary for a complete demonstration, but further remark is unnecessary here. The main point is that the mean effective pressure which gives the best economy must be known for the initial and exhaust pressures that are to prevail, and cylinder sizes selected that will enable the engines to carry the load with such mean pressure, for best average conditions.

The need for some specification as to mean effective pressure limits is well demonstrated by the bids received recently on a call for proposals on unaflow engines. Seven builders submitted bids, and the mean effective pressures at full rated load varied from near fifty pounds to over seventy. This meant that some makers were willing to risk small cylinders that would be overloaded under loads which would amount to only about three-fourths load for the larger engines offered by other companies. The builders were not necessarily to blame since it was not specified at what load maximum economy was desired. They had to make their own assumptions as to whether the purchaser wanted best economy at half the rated load, at full load, or some other fraction of rating. This places conservative builders at a disadvantage and is likely to bring in bids that are attractively low on small cylinders, which bids cannot be rejected without strong argument and some embarrassment.

Such a situation may be avoided by stating in the specifications either the maximum mean effective pressure for the rated full load or the fraction of full load at which it is required the engines shall have maximum economy. If the writer of the specification is not informed as to what the mean pressure is that will give the desired condition, then he will take the latter method. But it is of the greatest importance that one of these requirements should be stated, if engines are to be secured that will conform to an accurate selection of units under the data furnished by a correctly drawn load demand curve. Only thus may intelligent plant designing be realized.

In the opinion of many people the matter of rotative speeds assumes importance. It is entirely possible that special considerations may warrant a fixed requirement here, but in general it is not necessary. The same may be said regarding various other engine proportions, such as pins and bearing dimensions. Standard designs developed by responsible manufacturers are to be used, and it is the part of wisdom to take them as they come. The purchase specifications should contain the stipulation that each bidder shall submit complete information on these points, however, and on the basis of the information thus received comparisons may be made. Differences here may become the basis for final selection between units that are close together in price.

Guarantees on steam consumption must, of course, be stated in the proposals. With alternating-current generators it is customary to state the performance in terms of kilowatt-hours on the basis of an 80 per cent power factor. Since this factor is liable to variation under motor loads on a three-phase system, it is desirable that the steam consumption should be stated for both engine-horsepower and kilowatt-hours of actual generator output. This protects both the purchaser and the builder of the engine.

It is in the analysis of the bids that good sense and

intelligence must be applied. The tendency to accept low bids is strong, and many times the care and scientific methods exercised in the preliminary work on the projects are frustrated by business executives who do not see beyond the size of the figures written into the purchase contract. There is a duplication of terms which sometimes confuses the uninitiated. We need to get away from it. On the surface it appears to be a matter of paying a price for equipment to generate so many horsepower or kilowatts. We express the situation in that language. What we are really doing is arranging to make an investment for a necessary part of the general plant equipment, on which investment the returns depend upon the sums paid annually for fuel, labor, supplies, repairs, interest and depreciation. Capital is a source of power for economic production which we possess in this country and which we must utilize if we are to hold place in the economic world. In this endeavor for economy in power, therefore, we must forget price for an isolated thing like power output and think in terms of investment and returns.

Influence of Steam Economy on Engine Value

We cannot enter here upon matters of reliability and general excellence in design. The private industrial concern has probably invited proposals from only such builders as are responsible and have for sale reliable goods. On public jobs the matter must be handled with courage and with regard to proper expenditure of money coming from the taxpayers. There is no real difference so far as the final result is concerned, although the engineer for the public has by far the more difficult task if he is honest.

From differences in steam economy, as indicated by guarantee figures supplied by bidders and from total power demand shown by the load curve, the extra steam required by the engines of lesser economy can be calculated. This is easily translated into terms of extra fuel cost on an annual basis. The influence of rotative speeds or other differences in design on length of operating life of the engine or any of its parts, and hence on repairs and depreciation allowances, must be estimated in accordance with the engineering judgment of the person charged with the analysis. Similarly, with differences in consumption of lubricating oil and other supplies. The net total difference in annual operating expenses obtained by combining these items stands as a charge against general income. It should now be capitalized by caluculating the investment sum on which it will pay a normal return to cover interest and depreciation. To illustrate: Let the amount of this annual difference in operating expense be taken at $300. Also assume as a normal interest charge, 6 per cent, and a rate to cover depreciation amounting to 7 per cent, the latter corresponding to an operating life of about fifteen years. The $300 would then pay the total return of 13 per cent on an extra investment of slightly over $2,300. As between two engines showing this difference in annual expense, one can afford to pay $2,300 more for the more economical unit.

Such an outline of the various steps involved in the design of plants and selection of equipment as has been given here contains nothing that is new or unusual in the practice of power engineers serving with companies in whose business power matters are of major importance. It has been prepared more as a means of calling attention to the significance of correct practices in the handling of problems common to industrial enterprises of moderate size. The ideas expressed have a real application in the many hundreds of plants that serve communities of small size and that are under the control of boards and commissions the members of which are without extended experience in business affairs. It is a plea for correct procedure in a matter that is vital in our economic welfare.

Cutting Fuel Costs

By George F. Swetnam

One seldom picks up in these days an engineering magazine that does not contain one or more articles on the formation, prevention, effects and removal of scale. Besides, there are numerous advertisements of scale removers and preventives. Occasionally, we see an article that mentions the cleaning of soot with the hand lance, but I have never yet seen the soot blower given its due in any magazine.

The soot blower has been in use but a short time compared with many pieces of power-plant equipment, and only in recent years has it attained any degree of popularity, but already more than 200,000,000 sq.ft. of boilers are so equipped. This is not surprising, as by the use of a good soot blower a saving of from 4 to 8 per cent in fuel can be effected, and an increase in overall boiler efficiency of 3 to 4 per cent can be obtained.

I believe there are two reasons why these figures cannot be equaled by the use of other methods. Many portions of a boiler, especially of a water-tube boiler, are almost inaccessible for hand cleaning, and hand cleaning cannot be done as often as it is advisable to do the work.

The manner of operation varies with the different kinds of soot blowers. There are, however, two general kinds, those with and those without automatically operated valves. Of course those with automatic valves will be handier, but the price is correspondingly higher, while the efficiency is practically the same.

With automatic valves the procedure is simple. There are usually five or six blower heads outside the furnace walls (automatic valves are not used on blowers for return-tubular boilers) from each of which a blower element extends through the wall and among the tubes. To operate the blowers, the drain valve is opened, which allows any condensation to escape; after closing the drain valve the main valve is opened. This admits steam to all the blowers. The blower element is then revolved by pulling an endless chain which turns a sheave wheel at the blower head. By means of a specially constructed cam the valve is opened when the nozzles on the blower element are directed at the part it is desired to clean, and remains open until they leave that part, when it closes. The chain is pulled in one direction only. When all the blowers have been operated, the main valve is closed again.

When the valves are not automatic, it is necessary to open a separate one for each blower, and the blowers are turned back and forth between set limits instead of making a complete revolution.

In selecting a soot blower, a number of points should be considered. I have prepared a list of eleven requirements, which are given herewith. They are not all the points to be considered, nor must a blower conform to all of them to be a good one, but they give a fair idea of what may reasonably be expected.

1. A soot blower should be efficient. It should be large enough to do the work assigned to it, and it should

be so constructed that it will do its work well, leaving behind it well-cleaned surfaces.

2. It should perform its work with as little steam as possible. If it wastes steam, the saving in fuel effected by its use is cut down.

3. It should be so arranged that as little condensate as possible will form in places not accessible for drainage. Cold condensate striking the tubes has a bad effect on the metal, while it is ruinous to arches and baffles. Besides this, it changes the soot to a pasty mass, making it difficult to remove.

4. All unnecessary bends in the steam piping should be omitted, so as to give the highest possible effective pressure at the blower nozzles.

5. The blower should be of simple construction. The more parts there are, the more time it will take to make replacements.

6. A blower should be easy to control, and the control should be positive.

7. It should not take more than one man at a time to work a blower without undue waste, and there is no reason why it should not be so arranged that it can be done as quickly as is consistent with good work.

8. The blower should be equipped with sufficient bearings so that it will turn easily. If the blower is hard to turn the operator is likely to turn it only part way.

9. A whistle or similar signal should be provided, so arranged that it works all the time steam is passing through the blower. This will make it impossible for anyone to forget and leave the steam valve open.

10. The materials and workmanship should be good. It is well to have the end plugs and the nozzles of the blower elements welded. All metal parts exposed to the heat of the furnace should be treated to prevent rusting.

11. The whole machine should be flexibly put together so as to withstand the strains of expansion and contraction without binding.

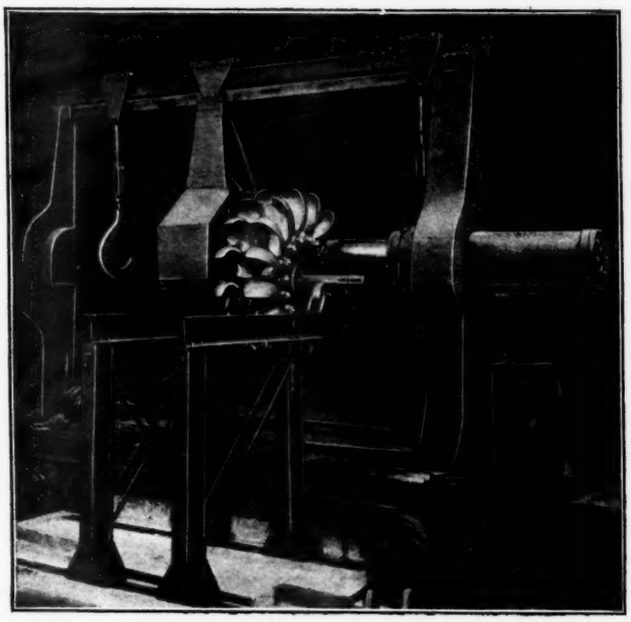
Connecting Buckets to Impulse Waterwheel Disks

With the growth in capacity and rotating speed of Pelton wheels or impulse turbines, a great many problems in designs have had to be met. One of the most important of these is the method of connecting the buckets to the wheel bodies. A better idea of the stress to which the bucket bolting is subjected can be understood with the realization that in a waterwheel bucket of modern design it is not unusual for each bucket to receive an impact from the jet equal to a total force of 45 to 50 tons at 250 to 300 blows per minute. Unless the bolting connection between the buckets and the wheel bodies is extremely rugged, the fastening will inevitably work loose and disaster will result.

To overcome this possibility, several methods have been devised. One is to screw the bucket lugs to a single central disk at the top of the wheel body by means of three fitted bolts each. This construction is objectionable for the reason that it is practically impossible so to fit each of the three bolts that each will be certain of taking its proper share of the stress.

A better construction reverts to the use of two bolts per bucket, the bolts being of such size that each will be able to carry its proportion of load with safety. Obviously, the two-bolt method of fastening eliminates the previously mentioned three-bolt objections. It is not always possible with the space available on the wheel body rim to put in two bolts of sufficient size to carry the load, since frequently the present-day high rotating speeds require the use of small-diameter waterwheel runners. The problem of sufficient bolting space for connecting the buckets and the wheel bodies is ever present.

A third method of fastening is the use of the chain-type construction. In this design the wheel body is made of two disks and the buckets have their forword lugs cast in a central position, fitting between the disks. The rear lugs saddle the outsides of the disks; thus in the bucket assembly a bolt passing through the forward lug of one bucket will also engage the rear lugs of the bucket in front of it, bearing in mind that this same bolt also passes through the two disks of the wheel body. It will be seen that an interlocking chain of the entire set of buckets is constructed with the bolts for pins. This interlocking design gives maximum strength and affords ample room for putting in bolts of any size that may be needed. The bolts themselves must be the finest kind of a body bound fit. To accomplish this, the pressing equipment shown in the figure has been specially constructed and is used by the Pelton Water Wheel Co. The press has a latitude permitting its use for pressing bucket bolts into wheels of all diameters and sizes from the smallest, as shown by the figure, to the largest, which may go up to 20-ft. diameter. Bolt pressures varying from 15 to 60 tons are used, dependent upon conditions.



BOLTS TO HOLD BUCKETS ARE PRESSED INTO PLACE AT PRESSURES VARYING FROM 15 TO 60 TONS

To install an angle thermometer to enable the temperature inside a cooled room to be read from the outside, place the thermometer so that only the metal attachment is at the outer side of the cold-storage room. The sleeve of the thermometer passage should be filled with insulating material so that there will be no possibility of heat being transmitted to the thermometer bulb from the outside. Put a glass front over the recess in the wall containing the thermometer.

Design and Operation of Underfeed Stokers*

DISTINCTIVE features of single and multiple-retort underfeed stokers and the principles of operation. Relative merits of various types of fan and setting heights for different makes of boiler.

BY H. F. LAWRENCE
Mechanical Engineer, American Engineering Company

UNDERFEED stokers are so designed that coal is fed from beneath the burning fuel. This is accomplished by feeding through retorts with adjustments so that the fuel bed is replenished through the length of the retort. The main feed from the coal hopper is accomplished with rams of fixed displacement so that the amount of fuel fed per stoker is fixed for a given coal, and therefore the amount fed per hour is accurately controlled by regulating the speed at which the rams are operated.

The first development of this type was the single-retort underfeed stoker, consisting essentially of a horizontal retort, into which fuel is fed from the hopper and distributed through the length of the retort. Tuyeres are placed around the edge of the retort, and through these air is supplied to the fuel under pressure from a fan. Dead plates or dump plates are placed on each side of the retort, from which the ash and refuse are removed. For wider furnaces intermediate inclined movable grates or tuyeres are placed between the retorts and the dump plates. These serve the purpose of providing more grate surface and also of depositing the ash and refuse on the dump plate. Single-retort underfeed stokers are now being manufactured and marketed by five concerns, Figs. 1 to 5 showing the various makes and their distinctive features.

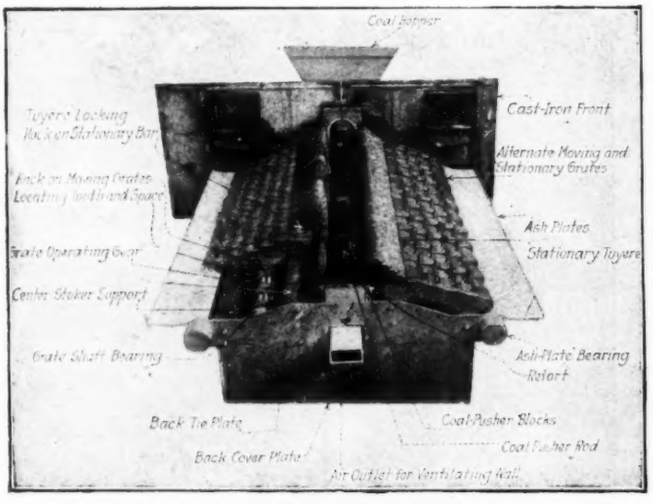


FIG. 1—STURTEVANT SINGLE-RETORT UNDERFEED STOKER

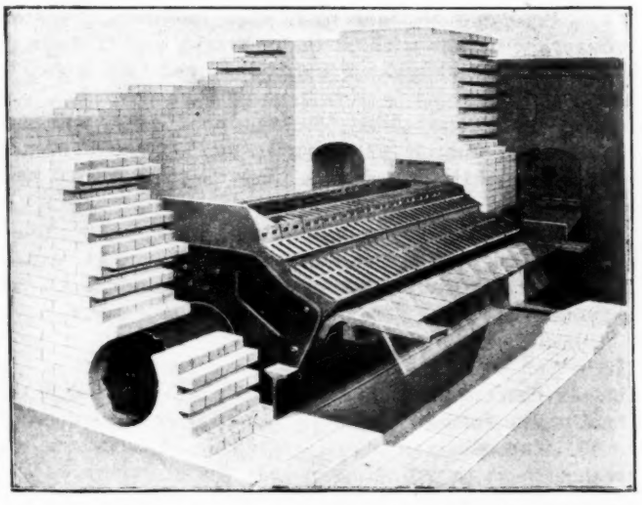


FIG. 3—DETROIT SINGLE-RETORT UNDERFEED STOKER

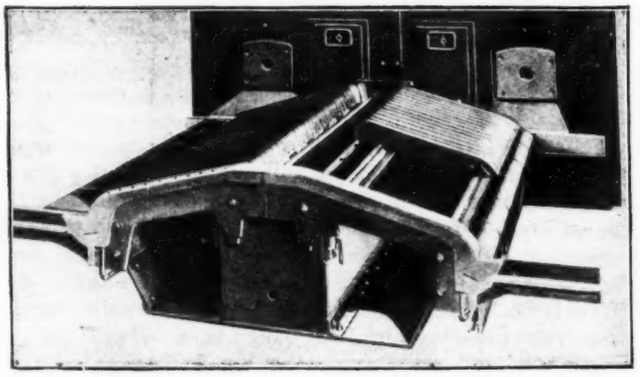


FIG. 2—TYPE E SINGLE-RETORT UNDERFEED STOKER

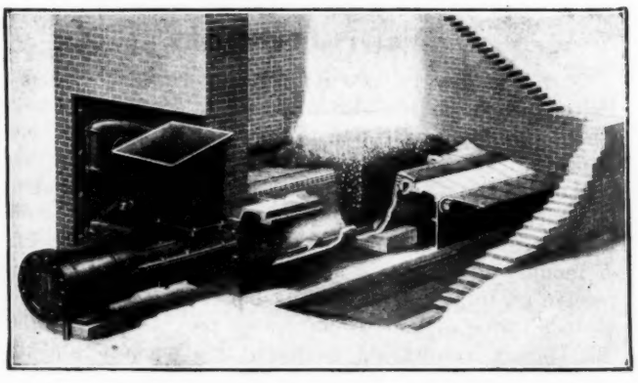


FIG. 4—JONES SINGLE-RETORT UNDERFEED STOKER

MULTIPLE-RETORT STOKERS

Multiple-retort stokers, being a development of the single-retort, consist of a number of single retorts placed close together and inclined with the ash discharge at the rear. As the coal is burned, the ash is formed on top of the fuel bed and is floated to the rear and deposited on dump plates or into crusher pits from

*Abstract of paper read before American Society of Mechanical Engineers, New York, Dec. 4 to 7, 1922.

which it is readily removed. The continuous ash discharge consists of rotary-toothed crushers placed at the rear of the stoker and set low so that a large, deep

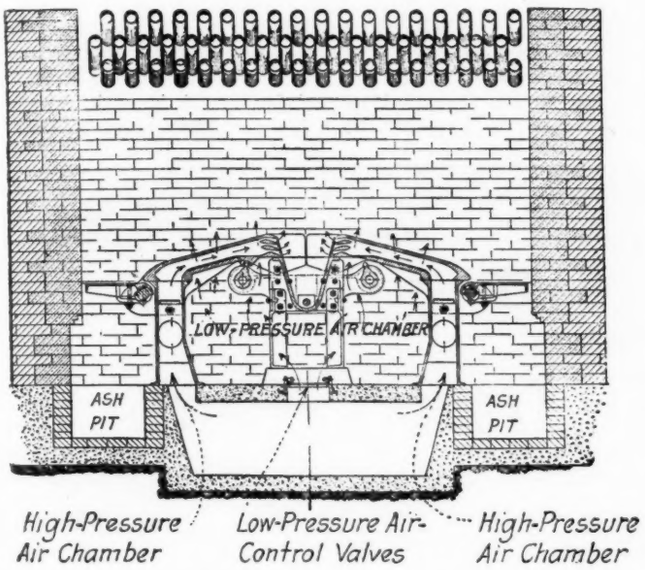


FIG. 5—ROACH SINGLE-RETORT UNDERFEED STOKER

pit is formed for receiving the ash and burning out the last of the combustible material.

The secondary coal feed—that is the feed from the retort to the fuel bed—is obtained in various ways. The Taylor stoker uses additional rams similar to the coal-feeding ram, which are placed in the bottom of the retort. The retort inclination is such that the new rams are reciprocated horizontally. The Westinghouse and the new Frederick stokers have a lesser inclination, and the secondary coal feeding is accomplished by large wedge-shaped castings placed in the bottom of the retort. These are reciprocated on an inclination corresponding to the slope of the bottom of the retort.

Arrangement of Tuyeres

Jones and Detroit stokers have similarly shaped retorts, and the secondary coal feed is obtained by small wedge-shaped pushers which are reciprocated horizontally in the bottom of the retort. The Riley stokers accomplish the secondary feeding by reciprocating the retort sides and the tuyeres.

Tuyeres are placed between the retorts and serve to convert the static head of air into velocity and direct the flow of air through the fuel bed. The tuyere designs naturally are different in each stoker. They vary in the angle of the tuyeres—from horizontal in the case of the Detroit stoker to an angle of 25 deg. in the Taylor stoker.

Figs. 6 to 11, inclusive, show various makes of this type of stoker and their essential differences in design.

The operation of underfeed stokers is essentially as follows: The incandescent burning fuel is on top and is replenished throughout the entire retort length from beneath. As the coal emerges from the retort, it is coked and spreads over the tuyeres, forming a homogeneous fuel bed across the entire furnace width. As the fuel approaches the surface, the volatile matter is distilled off and the fuel is coked. The surface consists of a layer of incandescent burning coke. The air for combustion is introduced near the point where the fuel emerges from the retort. As the volatile gases are liberated, they are thoroughly mixed with air. As the mixture passes up through the fuel bed, higher-temperature zones are reached and complete combustion of the volatile gases takes place when they pass through the white-hot coke at the surface.

Smokeless Combustion Without Special Brickwork

Smokeless combustion is obtained without the use of special mixing or ignition arches or special brickwork construction. As the fuel bed is replenished from beneath the surface, the burning incandescent coke which is on top is slowly moved toward the dump plates. As the ash is formed, it is floated on the surface and is eventually deposited on the dump plates.

Control of the fuel bed is obtained by adjustments of the secondary coal-feeding arrangement. For good operation it is essential that the fuel bed be so controlled that the replenishing coal emerges from the retort through its entire length, the lesser amount being fed from the rear end of the retort.

With the low-grade Western coals more fuel must be discharged from the rear end of the retort than with the high-grade Eastern fuels. In general, the greater the quantity of ash in the coal the longer should be the stroke of the secondary fuel-feeding mechanism.

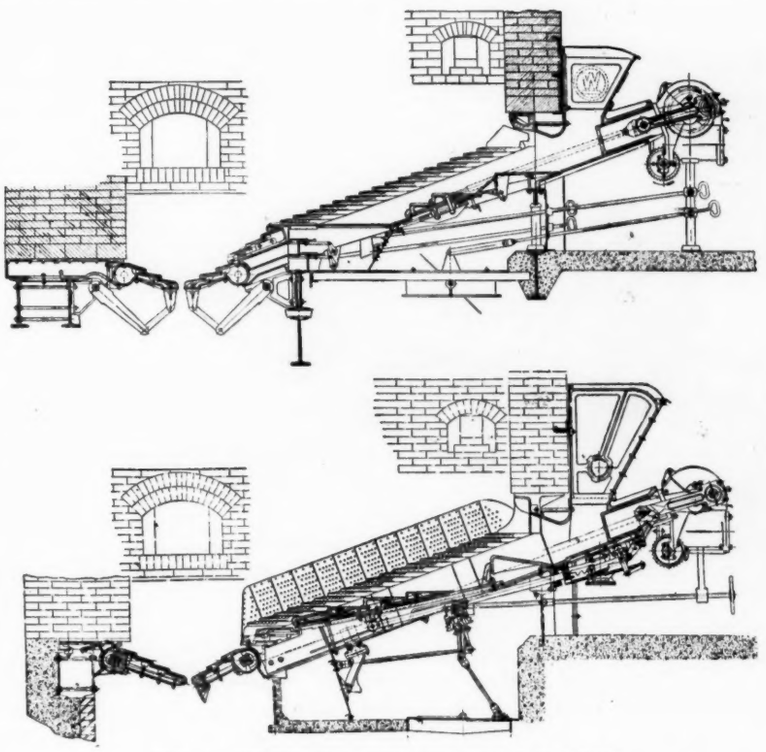


FIG. 6—WESTINGHOUSE MULTIPLE-RETORT UNDERFEED STOKER

Above, standard stoker; below, new model

If insufficient coal is fed from the lower or rear end of the retort, the ash, instead of being carried on to the dump plates, is deposited at the lower end of the

retorts, and as high fuel-bed temperatures are always obtained, the ash is clinkered, and when deposited at this point, it blocks the air discharge. After a short interval fuel from the upper part of the retort, which is not coked, is deposited over this clinker formation and then avalanches on to the dump plates. With this condition of fuel bed it is impossible to secure good results or good operation. With proper strokes of the secondary coal-feeding mechanism this condition can be

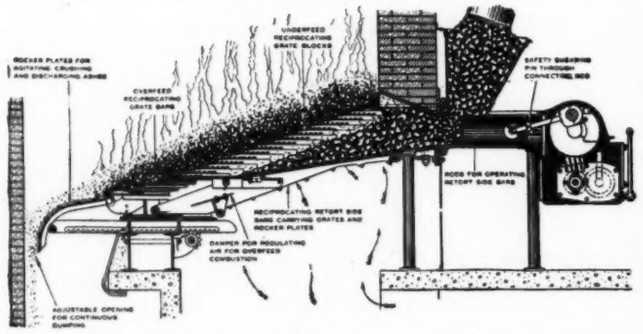


FIG. 7—RILEY MULTIPLE-RETORT UNDERFEED STOKER

eliminated, as with the proper amount of coal being fed from this action of the retort the ash and clinker can never be deposited at this point. This is really the important adjustment to be made for various grades of coal, and it probably receives less attention from plant operators than any other variable. When properly adjusted, the fuel bed is automatically kept clean, and high rates of combustion can be obtained.

With the underfeed stokers properly adjusted, fresh fuel will be fed up throughout the full length of the

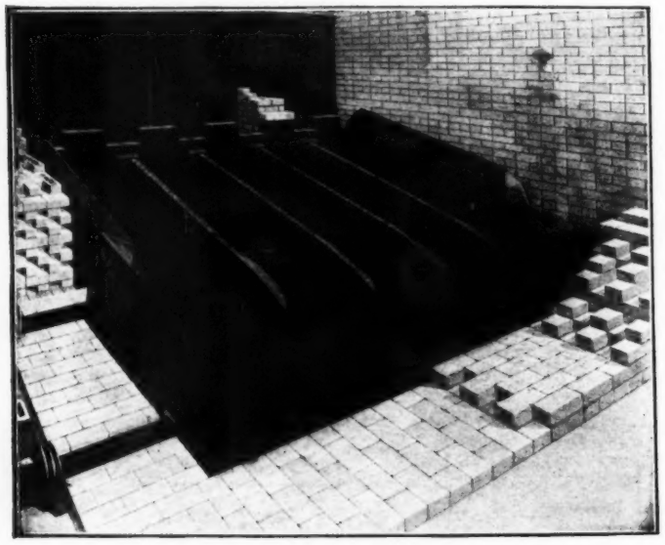


FIG. 8—JONES A-C MULTIPLE-RETORT UNDERFEED STOKER

retort. Green fuel moving upward with respect to the tuyeres tends to keep them buried, and consequently the ironwork is in the comparatively cool zone of the fuel bed. For this reason the maintenance is low on underfeed stokers.

With the underfeed system of combustion the excess air required can be reduced to a minimum, which means that high fuel-bed temperatures are obtained. The fuel-bed temperature will probably always exceed the ash-fusion point of any of our coals. This means that clinker must be formed in order to secure the best combustion results.

These stokers are designed to handle clinker and maintain the fuel bed clean at all times, and it is the duty of the operators to keep them so adjusted that clinkers do not get down in the fuel bed where they might do harm.

There are several types of fans used in stoker service, each of which has different characteristics (see

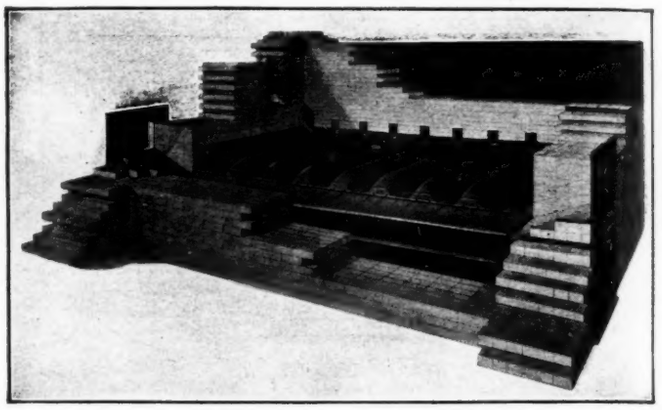


FIG. 9—DETROIT MULTIPLE-RETORT UNDERFEED STOKER

Fig. 12). The high-speed fan with narrow forward curbed blades (*a*) has a wide range of volume delivered with only slight variations in the static pressure, but is not well adapted for use on underfeed stokers. Owing to this pressure characteristic, with two or more of these fans operating together it is practically impos-

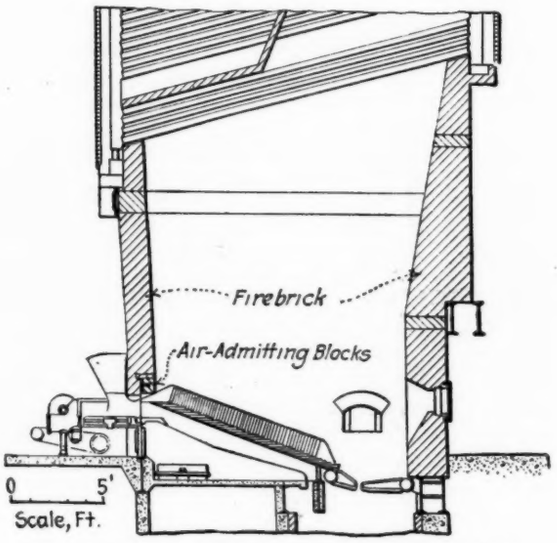


FIG. 10—NEW FREDERICK MULTIPLE-RETORT UNDERFEED STOKER

sible to keep them in parallel operation. It will be noticed that this fan also has a rapidly increasing horsepower requirement as the static pressure drops and the volume increases. This would be satisfactory for a motor drive only if an exceptionally large motor were used. If for any reason the pressure should drop, the volume and horsepower would increase so much that the motor would be overloaded. This is a condition that should be avoided.

The radial-tip fan (*b*), which is also a narrow-bladed

high-speed fan, has similar characteristics to the forward-curved blade fan so that it also is likely to overload the motor at low pressures.

The partial-backward-curved fan (*c*) which is high speed, and also the steel-plate fan (*d*) (low speed) have characteristics that are satisfactory, owing to a steeper pressure curve. The horsepower increase is not abnormal for a drop in pressure, and these fans will operate in parallel without trouble.

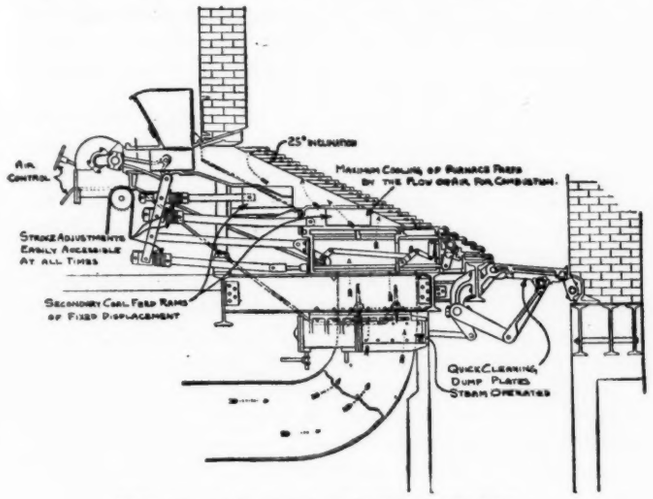

Air Control
25° Inclination
Stroke Adjustments Easily Accessible at All Times
Secondary Coal Feed Rams of Fixed Displacement
Quick-Clearing Dump Plates Steam Operated

FIG. 11—TAYLOR MULTIPLE-RETORT UNDERFEED STOKER

The full-backward-curved fan (*e*) with long blades, which is also a high-speed fan, has the best characteristics for stoker service. It has a steep static-pressure curve, together with a comparatively flat horsepower curve, and has the additional characteristic that after reaching the maximum horsepower any further increase in volume, due to reduction of static pressure, will reduce the horsepower required. The smallest-sized motors can be used safely on this type of fan, and it also has the highest efficiency.

For a fan operating against a constant resistance the power varies as the cube of the speed, the static pressure as the square of the speed, and the volume directly as the speed. In underfeed stoker practice, however, the resistance is not constant, so that the fans do not follow this law.

Fig. 13 shows in the dotted curves the volume and pressure characteristics in accordance with the constant-resistance law, while the full-line curves show the volume and pressure characteristics at the stoker connection. These curves have been plotted from data obtained in actual stoker tests.

For all types of boilers the Stoker Manufacturers' Association, in conjunction with the American Boiler Manufacturers' Association, has adopted minimum setting heights, which are given in Table I. Setting heights for the different types of boilers are defined in Table II.

Frequently, the combustion space required is stated as a function of the coal-burning capacity. This is misleading, since it leaves out of consideration all conditions that are imposed by the arrangement of the boiler baffles and stoker in relation to one another. It is desirable to keep the velocity of the rising gases in the furnace as low as possible, but a larger horizontal furnace section, with consequent large volume, may not necessarily do this. Ample height of the boiler above the stoker should be secured in order that combustion of the gases may be completed before they come in contact with the tubes.

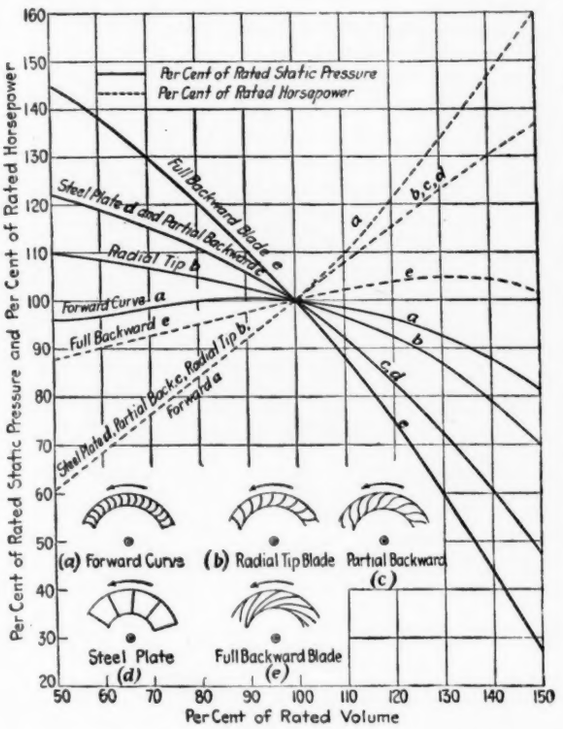

Per Cent of Rated Static Pressure
Per Cent of Rated Horsepower
Per Cent of Rated Static Pressure and Per Cent of Rated Horsepower
Per Cent of Rated Volume
Full Backward Blade e
Steel Plate d and Partial Backward c
Radial Tip b
Forward Curve a
Full Backward e
Steel Plate d, Partial Back c, Radial Tip b, Forward a
(a) Forward Curve
(b) Radial Tip Blade
Partial Backward (c)
Steel Plate (d)
Full Backward Blade (e)

FIG. 12——FAN CHARACTERISTICS AT CONSTANT SPEEDS

High setting heights impose a more severe service upon the brickwork. Extreme care must be used in designing the furnace walls, so that they will stand not only the high furnace temperatures, but also the

TABLE I—SETTING HEIGHTS FOR VARIOUS TYPES OF BOILERS EQUIPPED WITH STOKERS

(Min. = absolute minimum; P.M. = preferred minimum, i.e., the minimum heights recommended.)

Type of Boiler	Type of Stoker To Be Installed													
	Multiple-Retort Underfeed		Single Retort Underfeed				Side Overfeed		Front Overfeed		Chain Grates			
	Taylor Westinghouse, Riley, Jones A-C		Type E		Jones Single-Retort		Murphy, Detroit		Roney		Natural Draft		Forced Draft	
	Min.	P. M.	Min.	P. M.	Min.	P. M.	Min.	P. M.	Min.	P. M.	Min.	P. M.	Min.	P. M.
Water-Tube:														
Horizontal	10′	12′	10′	12′	8′	10′	8′	11′	8′	10′	10′	12′	12′	14′
Inclined (Hor. M.D.)	7′	8′	6′	8′	6′	8′	5′	7′	6′	8′	6′	8′	7′	8′
Inclined (Vert. M.D.)	5′	6′	5′	6′	3′ 6″	5′	3′ 6″	5′	3′ 6″	5′	3′ 6″	5′	6′	8′
Vertical (Hor. M.D.)	3′	4′	3′	4′	3′	4′	3′	4′	3′	4′	3′	4′	3′	4′
Vertical (Vert. M.D.)														
150-hp.	4′ 6″	5′	4′ 6″	5′	4′ 6″	5′	3′ 3″	.....	3′ 6″	4′ 6″	4′ 1″	4′ 7″	5′	5′ 6″
250-hp.	5′ 6″	6′	5′ 6″	6 3′	5′ 6″	6′	3′ 3″	.....	3′ 6″	4′ 6″	4′ 1″	4′ 7″	5′	3′ 6′
500-hp.	6′	6′ 6″	6′	6′ 6″	6′	6′ 6″	3′ 3″	.....	3′ 6″	4′ 6″	4′ 1″	4′ 7″	6′	6′ 6″
Horizontal Return Tubular:														
72-in.	8′	10′	8′	10′	7′	10′	7′	8′	6′	8′	7′	8′	8′	10′
84-in.	8′	10′	8′	10′	7′	10′	7′	9′	6′	8′	7′	8′	8′	10′

load. It is common practice at the present time to expose all of the first few rows of boiler tubes to the radiant heat from the fuel bed. This gives lower furnace temperature and greater life to the brickwork.

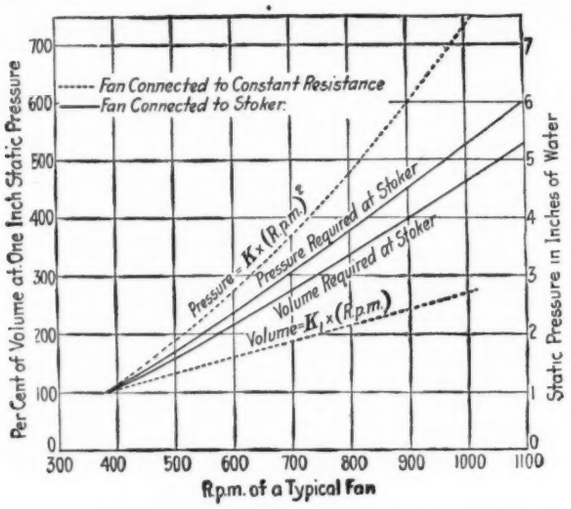


FIG. 13. RELATION OF VOLUME AND PRESSURE OF AIR TO FAN SPEED

No arch construction or special brickwork is required in the application of underfeed stokers, and in fact it is preferable not to have arches. On account of the differences in the coefficients of expansion of different kinds of brick, however, only one kind should be used in the furnace.

TABLE II—DEFINITIONS OF SETTING HEIGHTS FOR VARIOUS TYPES OF BOILER

Type of Boiler	Setting Height
Water-Tube, horizontal	Floor line to bottom of header above stoker
Water-Tube, inclined	Horizontal mud drum: floor line to center of mud drum
	Vertical mud drum: floor line to top of mud drum
Water-tube, vertical	Horizontal mud drum: floor line to center of mud drum
	Vertical mud drum: floor line to top of mud drum
Horizontal return tubular	Floor line to under side of shell

Proper provision must be made for taking care of the expansion as the setting heats up. The brick should be carefully sized so that thin joints can be obtained. Each brick should be dipped in a thin fireclay wash and tapped into place with a wooden mallet until it touches the bricks next to it.

Walls should never be so constructed that they overhang or lean toward the furnace. Walls that slope outwardly from the furnace will give much longer service.

Effective Regulation of Exhaust Steam System by Using a Low-Pressure Turbine

BY J. E. HOUSLEY

When a commodity such as exhaust or live steam is furnished to a factory production unit, the power house ceases to exercise control over the rate of use and amount of steam consumed. It is essential that close co-operation exist between the maker and the user of the steam since no appreciable storage of the product is ordinarily possible between the boiler and the point of use. A uniform rate of using steam is the goal, but it is seldom attainable in practice. Intermittent operation may occur in evaporators, usually considered a most desirable consumer, on account of the specific gravity of the liquid changing or the production chain calling for more or fewer units in operation; excessive variations in steam consumption occur where batch cooking operations are in use. At times a regular rotation of units prevails, while again some interruption of charging operations occurs and when an effort is subsequently made to increase the number of units under steam at the same time, the demand rises in a very short interval, from almost zero to a peak far above average consumption.

A severe test is thrown on the power house when the demand for exhaust steam is suddenly diminished, which in turn causes back pressure to rise immediately and operate the atmospheric relief valves. This does not always restore equilibrium, as the increased back pressure lowers the effective pressure on the piston of a reciprocating engine, causing a larger volume of steam to be used to develop the constant power required by the generator, possibly increasing further the pressure in the exhaust system. The sudden increase in steam consumption lowers the pressure on the boilers, and so it is apparent that the "vicious circle" continues until something "happens." This condition may occur in the space of two to five minutes where large reciprocating engines and chain-grate stokers are used.

THREE COURSES OPEN TO OPERATOR

It is undesirable to drop the load in order to restore equilibrium, and three courses present themselves: First, to prevent an appreciable rise in back pressure; second, to hold the boiler pressure up in the face of a greatly increased steam demand; third, shift part of the electrical load to a unit not feeding the back-pressure system. The latter plan was found to give the best operating practice in a power house containing one 3,000-kw. and one 1,500-kw. reciprocating unit on 160 lb. initial and 25 lb. back pressure. A 1,000-kw. low-pressure turbine was used in the nature of a balance wheel for the system, being "floated" on the line, carrying normally about 200 kw. and *not* being equipped with a governor. When the demand for exhaust steam diminished and the back pressure rose, a valve was opened between the 25-lb. back pressure system and the regular exhaust header supplying the low-pressure turbine and the feed-water heaters. The valve was regulated to distribute load between the turbine and the reciprocating units so that only enough steam passed through the engine to supply the 25-lb. system demands plus the amount consumed by the low-pressure unit; in other words it caused engines and turbine to act practically as one unit, bleeding into the 25-lb. system. In this manner steam lost to the atmosphere was kept at a minimum, voltage and frequency were held at normal and even boiler pressure and smooth operation of stokers was maintained. When this method was not practiced, it became necessary to open the 25-lb. system directly to the atmosphere in order to prevent dropping the load and the reducing boiler pressure to a point that the boiler-feed pumps could not operate. This method also dropped the back pressure to a point that seriously interfered with the operation of evaporators and other equipment using this service.

Where bleeder turbines are used, the regulation may be easily obtained by extracting only sufficient steam to supply the demand of the back-pressure system. However, reciprocating units alone do not produce a very stable system except with a low-pressure turbine as a balance wheel.

EDITORIALS

F. R. LOW, EDITOR

Power Factor a Problem in Economics

THE disadvantages of low power factor have been so widely discussed that they are generally appreciated by power engineers. But this element, like all others in the generation and distribution of power, is a problem in economics as well as efficiency. There are many things that may be done to improve the efficiency in a modern steam-electric power plant, but the saving in fuel will not pay the carrying charges on the improvements, and as a result the cost per unit output is increased. Consequently, before any improvement is generally adopted in power-station design and operation, it must have an economic value as well as increase the efficiency of the plant. So it is with the problem of maintaining high power factor—it must be worth while from a monetary viewpoint before there is going to be much of an incentive to adopt corrective methods.

An economic consideration of power factor has many angles, and where power is purchased, this involves both the power purchaser and the power company. If the power user overmotors his plant or installs large induction motors on drives where synchronous motors should be used, an economic blunder has been committed for which he must expect to pay the cost. Not only has the cost of the installation been made unnecessarily high, but the efficiency has been decreased so that the power consumption is higher than it would be were the proper sizes and types of motors selected. On the supply end the capacity of the electric equipment is increased, consequently the investment and cost of power are also increased. After the mistake has been made and the power user finds himself paying a penalty on his power bill each month where he might be receiving a bonus, it is still a question of "Will it pay to make a change?" If it doesn't, the average power user is likely to pay the penalty if it is the cheapest way out.

There are many installations where, no matter how carefully the load is motored, the power factor will be low owing to the wide variation in the load. The only way the power user can correct the power factor under this condition is by the installation of a synchronous or a static condenser. But before installing this equipment, the customer is justified in demanding proof that the saving in power costs will warrant the investment. With the power company there are a number of possible courses. A large synchronous or static condenser may be installed to correct the power factor of a number of loads on a feeder, or some customer, who has conditions favorable for doing so, may install a large synchronous motor or motors to drive mechanical loads and correct the power factor. On the other hand, if the system has considerable reserve capacity, the question of good power factor will not be of the same importance as if the limit of generating and distributing capacity were being reached and something had to be done to obtain more capacity. Under the latter conditions improving the power factor of the system might postpone the time of installing another unit and make the investment in corrective equipment an attractive one.

Undoubtedly, more concrete information is necessary than is available at the present time on the actual increase in the cost of generating and distributing power at power factors less than unity over that at unity, before the question can be settled on an economic basis. However, as pointed out by A. R. Stevenson, Jr., in his article, "Advantages of Good Power Factor," elsewhere in this issue, it will be difficult to induce the power user to make investments to correct poor power factor if he cannot be shown that the reduction in power costs will warrant the venture.

Steam Velocity— Shall We Guess or Know?

SHOULD the maximum steam velocity in a steam pipe be 6,000 feet per minute or 20,000? Obviously, it makes a lot of difference. If 20,000 is used where 6,000 should be, trouble is certain, while if 6,000 is used where 20,000 would give entirely satisfactory results, a lot of money is wasted on oversize piping, fittings, valves and pipe covering. To the resulting yearly increase in capital charges must be added the cost of the additional heat loss caused by larger piping.

Most of our formulas for the flow of steam through piping and fittings were inherited from the era of low pressures and saturated steam, and it is the opinion of many practical designers that they are totally inadequate for the conditions found in large stations. Moreover, it appears that the laying out of steam pipes on a velocity basis is satisfactory only where a wide range of velocities is used to fit various conditions

In this connection, considerable interest attaches to the recent statement of John H. Lawrence, who has had extensive experience in power-station design, that the proper steam velocities for the conditions found in the large modern power stations may be roughly approximated by allowing 1,000 feet per minute velocity for each inch of pipe diameter. If this rule is approximately correct, it is seen that 6,000 feet per second, while about right for a six-inch pipe is far too low for a twenty-inch pipe. This rule of thumb was not proposed by Mr. Lawrence as a hard-and-fast law of good practice, but merely as something tangible in the field between pure guesswork on the one hand and incorrect formulas on the other. In reference to the latter Mr. Lawrence said that actual measurements at the Hell Gate Station showed pressure drops far lower than those figured by any of the standard formulas for steam flow. As to losses through fittings and valves, the condition of knowledge is, he said, even more chaotic.

Such a situation demands investigation, and it is to be hoped that the A. S. M. E. (co-operating with the manufacturers) will follow the suggestions of those members who are fully alive to the importance of this

problem. Whether or not it proves feasible to construct apparatus for laboratory research work of sufficiently broad scope, it should certainly be worth while to make an extensive field survey to determine the actual pressure drops obtained with the various fittings, pipe sizes, pressures, superheats and steam velocities found in existing plants. From a careful study of the tabulated data of such a survey, it should be possible to develop formulas suited to the needs of the practical designer.

"It Pays To Be Particular"

MODERN power machinery is constantly being improved with regard to facility of operation, so that the efforts of one man surrounded with automatic control systems and safety devices can produce results equivalent to those obtained from ten or perhaps one hundred men of the not very distant past. On the other hand, maintenance work, when it must be done, is not always of the kind that an average engineer can handle. For example, the repairs of various kinds of instruments in a large power house would require several varieties of "experts."

Aside from the more highly trained men required upon occasions, a greater factor than skill itself has become recognized in many quarters; namely, the necessity for doing things "right." Where the power supply for a large area possibly affecting portions of two or three states is liable to be temporarily discontinued owing to a small accident, it soon becomes recognized that successful operation rests on taking "no chances," although that desired condition is seldom or never really met in practice. It does not pay to temporize, use makeshifts or expedients when the source of the trouble itself can be removed, even if it requires far greater effort.

While we have learned the lesson of the high cost of power interruption and consequently give ample attention to operating troubles, it is not always realized that care and pains taken *before* trouble arises is not only as good, but generally a better investment. For instance, the period of installation of a turbine unit is the most important with regard to future reliability. It does not pay nowadays to pass an alignment measurement as "good enough" in order to avoid the expense and delay incident to moving a doweled bearing or other support. All adjustments and minor machine work should be made with the idea of representing the greatest practical accuracy and dependability. A prime mover that runs "perfectly," as the operating man would say, may sometimes be the result of good fortune, but is nearly always due to conscientious work in the factory and power house.

A clear-cut case is recalled where what was then termed a "large" turbine unit was installed in a small town, being the only unit of its kind for many miles. It had given trouble in a previous location, and its operation was watched with interest. The erecting man followed closely the manufacturer's instructions and corrected alignment accurately, involving much machine work and some delay, but a pleasant surprise was experienced when it "started off" in a flawless manner and operated for a long period without the necessity of any further adjustment of the various mechanisms. The "old man," as the erector was termed behind his back, explained matters by the fact that they had taken great pains with all adjustments for, as he always put it, "It pays to be particular."

The Solid-Injection Oil Engine

IT IS the belief of many that the solid-injection oil engine is merely a Diesel engine with the air compressor eliminated. To the contrary the two bear little resemblance to each other and work on entirely different cycles. As pointed out by H. F. Shepherd in his discussion on the "Development of the Solid-Injection Oil Engine" on another page, the solid-injection engine is an evolution of the primitive hot-bulb engine; it is, then, actually a development rather than a retrogression in engine design.

The problem of building the solid-injection engine is not merely one of increasing the compression pressure to a point when the oil will self-ignite. In fact, engines have been built with this as the basic idea, but have proved absolute failures, to the bewilderment of the designer.

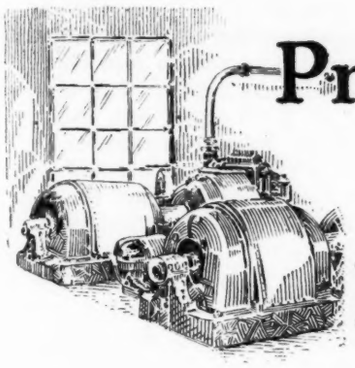
Apparently, there are two underlying principles that must be adhered to if the engine is to function satisfactorily. In the first place the atomization of the fuel must be superior to that usual in the hot-bulb engines in order to enable the oil particles to meet with sufficient oxygen to complete combustion. At the same time, since the only means whereby the oil may mix with the mass of dense compression air is by its own velocity energy, the atomization must not be as perfect as in case of the Diesel engine, where the injection air acts as a vehicle to convey the nebulized oil into the air mass, and there must be sufficient turbulence to give thorough mixing. The second principle is that the oil spray must not be permitted to strike the cold walls of the combustion chamber.

The successful carrying out of these underlying principles guarantees the success of any engine. As pointed out by Mr. Shepherd, while the several engines now built differ in construction, all solve or attempt to solve the problems outlined. All may not agree with the belief that the drift is toward air injection, for there are an increasing number of firms taking up the solid-injection engine. That the present-day hot-bulb engines will be developed into the solid-injection engines for small and moderate powers is quite true, but it is not so evident that the development will continue to the point that the engines will be converted into air-injection units. That the larger engines, say above three hundred horsepower, will continue to be true Diesels is indisputable.

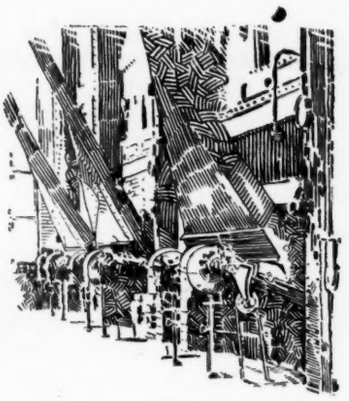
The following appeared recently upon the editorial page of a leading metropolitan paper:

About eighty per cent of the heat generated by the combustion of coal is lost—goes up the chimney. But there are signs that much of this waste is to be stopped by improved methods in its use. A device that will cut out forty per cent of the waste would make an enormous fuel saving. Of all things the modern locomotive is said to be the most prodigal waster of coal.

From fifteen to forty per cent of the heat generated for power purposes goes up the chimney. A much smaller proportion of that burned for domestic heating is lost, and recent investigations show that even the open fireplace is not so bad an offender as was supposed. The chimney structure and contiguous walls absorb much of the heat from the gases before they reach the chimney pots, and give back to the building. Even the locomotive shows some surprisingly good results for a non-condensing steam plant on wheels and subjected to various external conditions.



Practical Ideas *from* Practical Men



Generator Could Not Be Synchronized

Troubles not always resulting disastrously, arise from synchronizing, one instance occurring where a damaged potential transformer had just been replaced by a new one. When a large generator, which had previously been synchronized without difficulty, was paralleled by using the new transformer a severe disturbance occurred and it proved to be impossible to parallel the generator. Luckily no damage resulted from the attempts made to parallel; and examination of the connections disclosed that the transformer had been so connected that the synchroscope gave an incorrect indication.

It appears from this that regardless of how certain a wireman may be that connections are correct, synchronizing should never be attempted until tests have proved that such connections are correct.

Belden, Calif. RALPH BROWN.

Frozen Brine Cooler

Many engineers do not understand the relation of brine strength to the temperature to be carried in a brine cooler. This was impressed upon me recently when going to work in a refrigerating plant.

The second night the fireman informed me when I came on watch that two of the coils of the double-pipe brine cooler were shut off since they had frozen up. After looking the cooler over, I closed the return valves in the engine room and opened up the expansion valves wide, so that the coils were flooded with liquid ammonia at high pressure. I next opened the return valves as wide as the compressor could stand. After allowing the plant to run in this way for a time, I poured warm water on the return bends of the frozen coils until the frost disappeared, showing that the brine was no longer frozen. The valves were reset to their regular operating position, and no more trouble occurred that night.

The next evening, when I went to work, I found that the coils were again frozen. I ventured to inquire of the chief engineer the cause of this trouble, but he could offer no explanation. In answer to my questioning he said that the brine was 70 deg. by the salometer and that the ammonia pressure in the coils was never below 10 lb. gage. This evidently was the reason for the frozen coils. As shown by the accompanying table on calcium-chloride solutions, a salometer reading of 70 deg. indicates that the brine will freeze if carried at about 8.5 deg. F. This temperature is the boiling temperature of ammonia at approximately 23 lb. gage. Even with a temperature difference between the brine and the ammonia of 3 deg. the ammonia must not be lower than 20 lb. gage. Of course, if the temperature of the brine entering the cooler is high, it is possible to carry a lower ammonia pressure, since in all probability the difference in the outgoing brine and the ammonia temperatures will be as much as 10 deg., which would allow a coil pressure of 14 lb. gage.

PROPERTIES OF CHLORIDE OF CALCIUM SOLUTION

Specific Gravity at 64 Deg. F.	Degree Beaumé at 64 Deg. F.	Salometer Deg. at 64 Deg. F.	Per Cent of $CaCl_2$	Freezing Point in Degrees Fahrenheit	Ammonia Gage Pressure Pounds Per Square Inch
1.007	1	4	0.943	+31.20	46
1.014	2	8	1.886	+30.40	45
1.021	3	12	2.829	+29.60	44
1.028	4	16	3.772	+28.80	43
1.035	5	20	4.715	+28.00	42
1.043	6	24	5.658	+26.89	41
1.050	7	28	6.601	+25.78	40
1.058	8	32	7.544	+24.67	38
1.065	9	36	8.487	+23.56	37
1.073	10	40	9.430	+22.09	35.5
1.081	11	44	10.373	+20.62	34
1.089	12	48	11.316	+19.14	32.5
1.097	13	52	12.259	+17.67	30.5
1.105	14	56	13.202	+15.75	29
1.114	15	60	14.145	+13.82	27
1.112	16	64	15.088	+11.89	25
1.131	17	68	16.031	+ 9.96	23.5
1.140	18	72	16.974	+ 7.68	21.5
1.149	19	76	17.917	+ 5.40	20
1.158	20	80	18.860	+ 3.12	18
1.167	21	84	19.803	− 0.84	15
1.176	22	88	20.746	− 4.44	12.5
1.186	23	92	21.689	− 8.03	10.5
1.196	24	96	22.632	−11.63	8
1.205	25	100	23.575	−15.23	6
1.215	26	104	24.518	−19.56	4
1.225	27	108	25.461	−24.43	1.5
1.236	28	112	26.404	−29.29	1-in vacuum
1.246	29	116	27.347	−35.30	5-in vacuum
1.257	30	120	28.290	−41.32	8.5-in. vacuum
1.268	31	...	29.233	−47.66	12-in. vacuum
1.279	32	...	30.176	−54.00	15-in. vacuum
1.290	33	...	31.119	−44.32	10-in. vacuum
1.302	34	...	32.062	−34.66	4-in. vacuum
1.313	35	...	33.	−25.00	1.5 lb.

We increased the brine strength by adding more calcium chloride, and there have been no more frozen coils.

Denver, Colo. R. L. CORNELL.

Failure To Shut Off Ejector Causes Low Temperature of Feed Water

Recently, in the operation of our plant we had a rather novel experience. The temperature of the boiler-feed water leaving the heater is usually maintained around 208 deg. This suddenly dropped to about 145 deg. and remained close to that point for two days, and we were unable to locate the trouble.

The heater is of the open type, and the exhaust steam is supplied from the turbine drives on the auxiliaries. During the time the temperature was low, the normal supply of water and exhaust steam was passing through the heater, so the cause of the drop in temperature of 63 deg. F. was rather puzzling. However, after two days' search the trouble showed up itself. One of the main units has a jet condenser fitted with an ejector from the air pump, which discharges into the main exhaust line. This unit was shut down on the morning the feed-

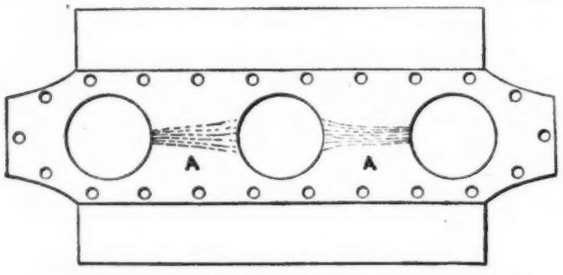
water temperature dropped, and the operator failed to shut off the ejector. When this unit was started up again, the feed-water temperature returned to normal. This proved that the cold air drawn through the condenser by the ejector and discharged into the exhaust line to the heater had caused the lower temperature of the feed water.

ALBERT C. TRAUTMANN.

Meriden, Conn.

An Unusual Pump Trouble

Recently, one of the triplex boiler-feed pumps in our plant failed to deliver water. Our first step in locating the trouble was to open the valve chambers and grind in the valves and seats. After this was done, the



GASKET WAS BLOWN BETWEEN CYLINDERS

pump appeared to operate all right, but still it would not pump water. It was then noticed that an unusual knock had developed on the wrist pins of the center plunger. This plunger was removed from the cylinder, the suction and discharge valves were blocked, closed, and the pump started up.

By looking down in the cylinder, water could be seen to come through the joint at the bottom at every stroke of the other plungers. The flange bolts were then removed and the cylinders lifted off the base, when it was seen that the gasket was blown through at *A*, as in the cut. The joint was cleaned, and a linen gasket (rubbed full of white lead) was put on and the pump reassembled.

M. M. BROWN.

Camden, Me.

Should Steam for Heating and Process Be Charged to Power-Plant Costs?

The company with which I am connected charges all costs for generating steam to power costs, regardless of what the steam is used for. This, in my opinion, is unfair. Our generating equipment consists of a 2,000-kw. turbo-generator unit operating on a steam pressure of 190 lb. at the throttle and 100 deg. superheat. The plant operates 55 hours a week and the load averages around 1,350 kw. with a power factor of 67 per cent. Our boilers are hand-fired, and we get an average evaporation of 6 lb. of water per pound of 13,000 B.t.u. coal. Approximately 3,000 lb. of steam is used per hour in the mill for process work the year round, and during the winter months about 7,000 lb. per hour is required for heating the mill. This steam is usually kept on 24 hours a day. Now the management charges the cost of making steam for heating as well as power, to the power costs. In my opinion the coal necessary to generate steam for heating and process work should be deducted from the total consumption and not charged against the plant. The company also has fifty-four dwelling houses for its employees, and it allows each a flat rate of 50c. a week for current. During the day the current is supplied from the plant, but at night it is taken from the city service. The city light bill will average about $120 a month, and this is also charged to our power costs. The company receives $27 a week for the current supplied to the houses, but does not credit the power plant with it. In spite of these charges our power costs average only 1.5c. per kw.-hr. This cost I think is reasonable, but I would like to have the opinion of some readers of *Power* on this point and also on the proper distribution of costs.

Henderson, Ky. JOHN MACONNELL.

Curing Water Hammer in Deep-Well Pump

An engineer operating a deep-well pump with compressed air at a pressure of 80 lb. gage, experienced some trouble on account of water hammer. The operating cylinder was fitted with a quick-closing valve gear. The diameter of this cylinder was 7 in., the stroke, 36 in. and the speed 36 strokes, or 108 ft. of piston travel per minute, which is fast for a pump of this type.

The pump was of a single-acting type which discharges most of the water on the up stroke, the flow stopping when the plunger reaches the upper end of the stroke and being partly resumed, owing to the displacement caused by the large cross-section of the plunger rod, when the plunger is on the down stroke.

This irregularity of flow no doubt accounted for much of the noise. At any rate the noise was practically abated by attaching an air chamber made of a piece of 4-in. pipe, to the discharge line, as shown in Fig. 1. A ½-in. pipe connecting the air chamber with the pipe that conveyed the compressed air for running the pump, provided a means for recharging the chamber in case it became full of water owing to absorption of the air by the water.

Later on, however, the pump began to pound worse than before; the noise and jar could be heard for a considerable distance. The pound seemed to occur when the plunger was about one-half way along the down stroke. This condition followed an overhauling of the outfit, in which the water cylinder and suction valve

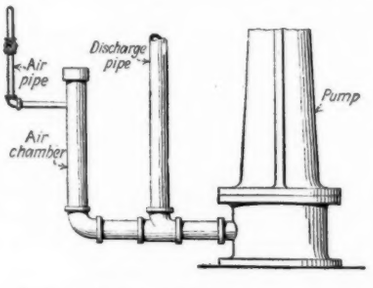


FIG. 1—AIR CHAMBER ATTACHED TO DISCHARGE PIPE

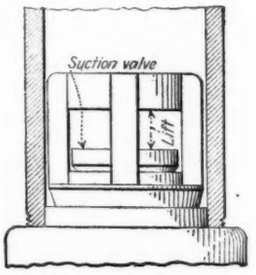


FIG. 2—POPPET SUCTION VALVE

at the bottom were renewed, a bevel-seated poppet valve having been installed, as indicated in Fig. 2, in place of the original ball valve.

The engineer concluded that the pounding might be due to the suction valve's having too much lift. This would let the water in the discharge pipe rush back and follow the plunger a short distance before being stopped by the closing of the suction valve. Hence the pound. Diminishing the lift of the valve removed the trouble.

A. J. DIXON.

St. Louis, Mo.

Comments from Readers

Some Important Factors Neglected

I cannot agree with Mr. Blakely's second item in the Nov. 21, 1922, issue of *Power*, in which he stated that baffles should be sloped to obtain nearly uniform velocity of gases through water-tube boilers.

Tests have demonstrated that the lower the temperature of the gas the higher the velocity must be to impart a certain amount of heat. Consequently, the velocity of gas travel in a water-tube boiler should be increased toward the last pass if the maximum heat energy is to be extracted from such gases.

The drop in temperature across the different passes cannot be made uniform, and consequently the gas velocity should not be made to increase uniformly.

The position of the baffles will vary in the same setting with different ratings at which the boiler is to operate, so that the baffles should be positioned for best results on the weighted average rating at which the boiler will be worked.

Item three is contrary to my experience. It is my opinion that the baffles do not need to be tight except to a practical degree. If the gas is forced within a distance of $\frac{1}{8}$ in. the heat will be absorbed by the tube. In other words if all gas would pass within this distance no baffles would be necessary. If the baffle is within that distance of the tubes and made of material that will resist cutting, the baffle is sufficiently tight and no trouble will occur on account of variations in expansion of baffles and boiler.

Chicago, Ill. H. E. WEIGHTMAN.

Why Does High Steam Pressure Produce a Click?

In the Dec. 19, 1922, issue J. A. Watt asks for suggestions as to cause of a clicking noise in the head end of an 18x30-in. Corliss engine running at 150 r.p.m., and he states that the click occurs only when the pressure is 130 lb. gage or above. In my opinion the click is caused by condensation coming over with the steam or too little clearance space on the head end of the cylinder.

There is a possibility that the steam pressure is too high to give good operating condition if only a light load is carried on the engine. If this is the case, the trouble could be overcome by installing a reducing valve in the steam line to reduce the pressure to about 110 lb. P. MOLLOY.

New York City.

I would suggest to Mr. Watt that he investigate the amount of end play between the valves and bonnets of both steam and exhaust valves.

By loosening the keys on the valve-stem arms and the setscrews in the collars on the valve stems and pushing the stems in toward the bonnets on the opposite side, he will doubtless find some end play. The valve may be pushed against the bonnet and the collar set to hold it in that position, without detrimental effects from expansion of the parts. Care should be taken in replacing the valve arms, that in driving the keys the stems are not pulled out again.

End play in the valves may cause anything from a slight click to a loud and disagreeable noise.

Vermillion, S. D. JOHN J. ELLIOTT.

Since the click occurs only when the steam pressure reaches a certain point and above that, it would indicate that the cutoff occurs too early in the stroke, and that the steam is being expanded below the pressure of the exhaust, in which case a loop diagram would be obtained. The click could also be caused from insufficient compression of the exhaust for good cushioning effect. This could be overcome by setting the exhaust valves so as to close earlier in the stroke.

McComb, Ohio. FOREST R. BURGOON.

Modern Methods of Installing CO_2 Recorders

On page 973 of the Dec. 19, 1922, issue the statement is made that "the one condition that contributes most toward the successful operation of indicating and recording CO_2 apparatus is that of tight joints in both apparatus and pipe lines." It has been our experience that considerable difficulty has sometimes been encountered in preventing leaks, but we believe that an equally important difficulty for years was proper filtration and conditioning of the gas sample prior to analysis.

We now advocate the use of seamless copper tubing with $\frac{1}{4}$-in. bore ($\frac{5}{8}$-in. outside diameter) for the gas sampling lines, whereas formerly brass pipe with $\frac{3}{8}$-in. bore (so called $\frac{1}{4}$-in. brass pipe) was the smallest size used, and often pipe as large as $\frac{3}{4}$ in. in diameter was employed. Three important advantages result from the use of small copper tubing: (1) It costs less and is simpler to erect; (2) it eliminates all joints excepting those on the ends; (3) the gas flow is speeded up so that the lag is only a fraction of what it was formerly. As a matter of fact the majority of our later CO_2 installations actually indicate and continuously record every change in CO_2 in less than three minutes after a change in furnace conditions has occurred. That is amply fast for all practical purposes, although it is possible to reduce the lag still further should it become necessary.

We also advocate the use of cocks instead of valves in the gas sampling line, as they obviate the possibility of leaks due to faulty packing.

The reason why we can use such small gas sampling lines now is because during the last two years we have developed a new method of filtering and conditioning the gas so that deposits of dirt and condensation of water are prevented from forming throughout the length of the gas sampling line and corrosion due to sulphur compounds in the gas is eliminated in the line from the gas

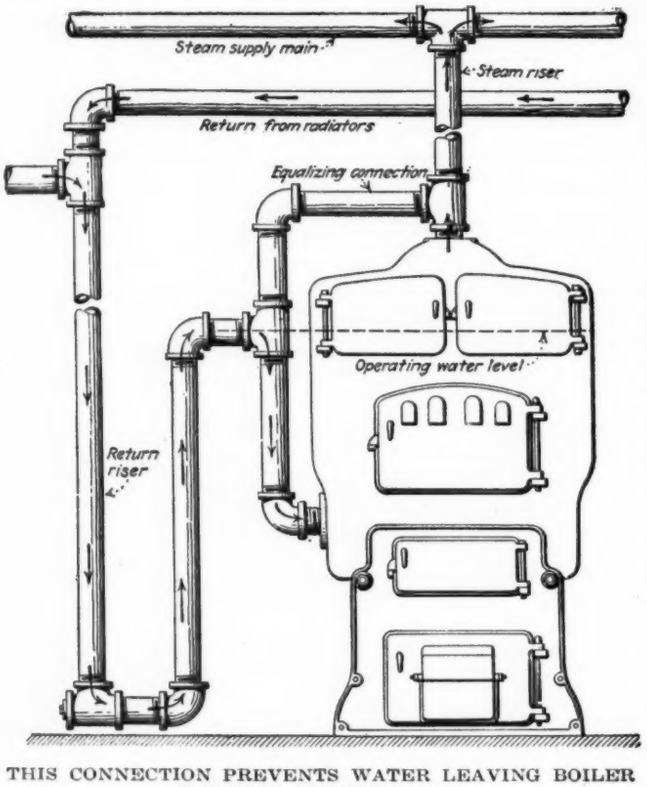
conditioner to the CO_2 machine. The filter[1] is placed on the extreme end of the gas sampling line within the boiler setting or flue and completely excludes soot and ash from the line. Most of the moisture condenses out in a drop leg in the line at the boiler and drains into a seal at that point. The remaining moisture as well as sulphur compounds are removed by the gas conditioner, which is placed as near to the boiler as practicable. Conditioning of the gas protects both the gas line and CO_2 machine against all the corrosion troubles that were common in earlier installations.

The modern method of installing our equipment, therefore, not only minimizes the possibility of such leaks as are referred to in the foregoing quotation, but also provides a perfectly clean and non-corrosive gas for the CO_2 recorder to analyze.

C. C. PHELPS,
Paterson, N. J. Uehling Instrument Co.

Trouble Caused by Water Leaving Heating Boiler

In the Nov. 14, 1922, issue P. R. asks why the water in a heating boiler goes out of sight when the presure is raised to 4 or 5 lb. This is undoubtedly due to overpressure. I assume that the system is an open vapor one, vented to the atmosphere at the return connection. Such a system requires but slight pressure, ½ lb. or less at the boiler even for the coldest weather.



THIS CONNECTION PREVENTS WATER LEAVING BOILER THROUGH RETURNS LINE

This system works all right if the boiler pressure does not rise above normal, but if overpressure occurs, the water is forced up the return riser if no check valve is used on the return connection.

If the return line is connected as shown in the illustration, no water can leave the boiler through this connection as the pressure is equalized between the return line and the boiler through the equalizing connection. This also obviates the need of a check valve.

Buffalo, N. Y. C. F. CLARK.

[This method of connecting water returns is similar to the one described on page 746 of the May 9, 1922, issue of *Power*.—Editor.]

My experience with water leaving a heating boiler has been similar to that described by Henry D. Jackson, in the Dec. 5, 1922, issue.

I have had some experience with heating systems in which the water would leave the boiler under 1 lb. pressure, but overcame this trouble by running the air line from the balance pipe up about 18 ft. into the chimney. Any pressure up to 3 lb. could then be carried without trouble from water leaving the boiler.

Hartford, Conn. WILLIAM H. SNYDER.

Behavior of A.-C. Generator When Field Circuit Is Opened

Referring to my contribution in the Nov. 14 issue and the editorial comment on it, I wish to add that my main object was to show that the loss of excitation under the stated conditions would not cause the generator to run as a motor. As to its action as a generator, my statement was based on what I had remembered reading several years previously in some articles covering that point. See "Flow of Electrical Energy," by R. A. Philip, a paper read before a joint meeting of the A.I.E.E. and the W.S.E. at Chicago, an abstract of which was printed in the Sept. 7, 1915, issue of *Power*, from which I quote the following:

> Where several alternating-current machines having direct-current excitation are connected together, the increase of excitation of any one machine tends to raise its voltage, but this tendency is counteracted by a magnetizing current which flows away from it to the other machines, demagnetizing it and magnetizing them. A considerable increase in excitation, therefore, produces a small though widespread increase in magnetization of all the machines. Conversely, a decrease in excitation of one machine causes an inflow of magnetizing power and a corresponding reduction in voltage of the whole system. This condition holds whether the machines are all alternators or all synchronous motors or a mixture of the two.
>
> Consequently, increasing the excitation of one of two alternating-current generators will not shift the load, and *an alternator may continue to carry its full load even if its excitation is lost.*

Under the title "Flow of Energy Through Transmission Lines," by the same author, what seems to be a slightly different arrangement of the same paper appeared in the May 1, 1915, issue of *Practical Engineer*. In the July 15, 1915, issue of the same, a subscriber asks for an explanation of this performance as a generator. The following quotation from Mr. Philip's answer in the same issue gives the values of the armature currents which he claimed would flow.

> When the direct-current excitation is cut off, the armature current of the generator will greatly increase, becoming 2, 3 or more times its normal amount. Many generators can carry such currents for a length of time sufficient to demonstrate the possibility of such operation, but cannot carry the currents continuously without burning out the armature.

I have never seen a generator lose its excitation under these conditions, but an experience with greatly reduced

[1]For description of this filter see *Power*, page 220, Feb. 7, 1922.

excitation of one machine in causing a large circulating current between machines may be of interest.

The plant had three turbo-generators—one 1,000-kw. and two 800-kw. machines—excited from one exciter controlled by a Tirrill regulator. The generators were normally operated with their field resistances all cut out. In raising the voltage on a machine to be cut in, it was necessary to cut out about half the resistance to bring the no-load voltage up to normal before synchronizing, and after closing the main switch the remainder of the resistance was cut out and the load applied.

One night immediately after synchronizing one of the 800-kw. machines and before putting any load on it, I noticed this generator's ammeters indicating 1,200 amperes (the normal full-load rating was 1,100 amperes) and a large increase indicated by the other machines' ammeters. This generator's wattmeter indicated zero and the others showed no increase in load, so I knew that for some reason I had the machines loaded up with cross-current. Upon examining the rheostat closely, I found that instead of having turned it to the "all out" position to correspond with those of the other two machines, I had cut the resistance all in again. Turning it to the opposite extreme position restored conditions to normal.

No doubt considerably more magnetizing power in the form of cross-current from the other machines would have been required to maintain this generator's voltage if the direct-current excitation had been cut off entirely, but I could not say how much. As it was, the circulating current exceeded the machine's full-load rating.

In the articles that I have referred to, nothing was said about the loss of direct-current excitation depriving the generator of its ability to hold in step, and allowing it to run above synchronous speed. That point seems to have been overlooked. I, too, had overlooked it entirely, my attention having been directed solely to the unexcited generator's ability to receive alternating-current magnetization from the other machines.

If its action as a generator would be that of an induction generator rather than that of a synchronous machine, the load that it could carry would be in proportion to the amount that its speed exceeded synchronism, which condition, in this case, would preclude the possibility of its carrying anywhere near full load, as the prime mover could not increase its speed without reducing its load. And its open-circuited rotor (direct-current field) would make it an imperfect induction generator even if it could increase its speed several per cent above synchronism with full power input from the prime mover. After giving this problem careful study, it seems to me that Mr. Graham's explanation of what would occur is correct.

H. G. ROBERTS.

Seattle, Wash.

Improvements at Plant of International Motor Company

My attention has been called to an article in the Nov. 21, 1922, issue of *Power*, concerning the improvement of the International Motor Co.'s power plant at New Brunswick, N. J. The writer was responsible for the operation of this plant during the greater part of the year beginning with June 1, 1918, and can perhaps supply some information concerning that period, which was not available to your informant or which, for one reason or another, was not considered relevant.

The actual coal consumption was 11,834 tons, or 904 tons less than recorded in your tabulation. This is a minor matter, however. A more important consideration is the quality of the coal. Anyone who operated a power plant during 1918 and 1919 can realize what that means. The best coal received during the year in question ran 13 per cent ash; some of the coal burned had an ash content of over 21 per cent. One carload contained 41.3 per cent ash and would not burn on these grates; while included in the 11,834 tons, it was not actually burned but carted to the dump. It is obvious that the coal in June, 1922, was pretty good, for unless it contained considerably more than 14,000 B.t.u. per pound as fired, the average boiler efficiency of this little 1,000-hp. plant equals the justly celebrated performance of the Colfax Station. This is assuming that the published evaporation of 10.71 lb. per pound of coal is correct.

The note under your table of figures, "Records of the Power Load not Available," is, to speak frankly, incredible. The records were carefully kept during the earlier years, and if they have been lost or if no records were kept during the later year, a reasonable comparison could have been made by consulting the files of the Public Service Corporation. I have obtained the following figures on power purchased at this plant, for the last three months:

	Maximum Demand, Kw.	Kw.-Hr. Consumption
September	787	230,500
October	818	221,700
November	705	212,100

The corresponding figures for the same three months in 1918 were:

	Maximum Demand, Kw.	Kw.-Hr. Consumption
September	1,300	538,000
October	1,375	631,200
November	1,425	479,100

The maximum demand in the fall of 1918 was, therefore, nearly twice as much, and the total power consumption more than twice as much in 1918 as at the present time. It is reasonable to suppose that other forms of power, such as compressed air, live steam for forge hammers, etc., were in proportion.

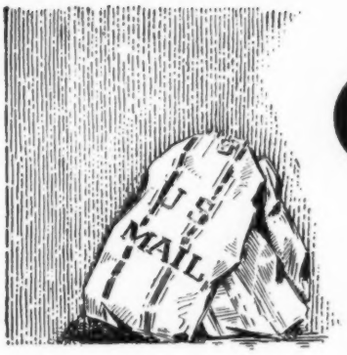
Another important factor affecting the fuel consumption in 1918 was the inability of the Public Service Corporation to supply the factory's power requirements. This necessitated running the engine generators at times when the exhaust steam could not be used. Two non-condensing steam air compressors, one rated at 1,100 c.f.m. and the other at 500 c.f.m., were run at 20 per cent overspeed all through the summer of 1918. Motor-operated compressors have since been added, which should materially reduce the fuel consumption for this service.

One more item in your article deserves mention. There were never at any time during the year mentioned, twelve firemen on the payroll. There were nine during the winter months, but during that period no "extra firemen" were employed. This is also a minor matter, accounting for only $4,800 of the estimated savings.

All this is written with no view of disparaging the very excellent improvements that have been made in this plant by Mr. Morrison. A correct comparison of present and past performance would undoubtedly show a very marked saving and a very attractive return on the expenditures for deferred maintenance and new equipment.

WILLIAM F. RYAN.

Boston, Mass.



QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

High and Low Pressure Bucket Trap

What is the difference in method of operation of a high-pressure and a low-pressure bucket trap?

F. M.

The principle of their operation is the same. Their main difference in construction is that the high-pressure traps are of heavier and stronger construction and the so-called "side lug" high-pressure traps are provided with extension lugs under the inlet and outlet passages to obviate the blowing out of gaskets at these points.

Simple Oil Tests

How can simple tests be made to determine whether dirt has been thoroughly filtered out of lubricating oil; also, what simple test can be made to determine whether an oil has a paraffin base? H. H. F.

For determining the amount of dirt in the oil, take about a half gallon of the oil in a clean vessel. Thoroughly agitate it and place a sample in a test tube or clean glass bottle with an equal quantity of gasoline. Shake the mixture well and allow it to stand for twelve to twenty-four hours. The dirt and sediment will settle to the bottom, but in any oil suitable for use the sediment should be only a small fraction of one per cent of the total volume.

To determine whether an oil has a paraffin base, place a small sample of the oil in a clear test tube and immerse the test tube in a bath of cracked ice and salt for about an hour. This should give a low enough temperature to cause a cloudy appearance to the oil if it has a paraffin base.

The cloudy appearance is due to settling of the paraffin wax that always is present in greater or less quantities in paraffin base oils.

Testing Discharge Valves of Vertical Ammonia Compressor

How can the tightness of the discharge valves of a vertical inclosed-type ammonia compressor be tested?

R. N. H.

To test discharge valves of inclosed-type compressors, close the ammonia suction stop valve and allow the machine to run about two minutes to expel all the gas from the crankcase and compressor. This should be done when the compressor and crankcase are free from frost. If the machine is frosted, there is likely to be a small quantity of liquid lying in the bottom of the compressor which will evaporate, causing pressure and spoil the test. After the machine has been shut down 15 minutes, hold a thumb over the oil intake pipe and slowly open the valve to see if it "sucks in" or has a good strong vacuum. If so, the gas is all out of the compressor. If gas blows out, start the machine again and let it run until there is a strong vacuum. Next, stop the machine, close the discharge stop valve and remove the water jacket and compressor head. If the discharge valve is tight, it will be held fast to its seat from there being a vacuum in the compressor. If it is loose, and there is no vacuum in the compressor, the valve leaks and will have to be ground in with flour of emery and oil. In doing this, care should be taken to remove all the emery, otherwise it may get into the cylinders or bearings and do considerable damage.

Evaporation of Lubricating Oil

Will a lubricating oil evaporate from becoming heated? R. C. M.

Like practically all liquids, lubricating oils evaporate with application of heat. Oils are made up of hydrocarbons having different boiling points and different surface tensions. Hence some oils evaporate faster than others, and the rates of evaporation are increased with a rise of temperature. The cooler a bearing can be kept the less the reduction of volume of the oil from evaporation, and for that reason bearings that are set up so tight as to run warm require more oil for their lubrication than when run cool.

Required Size of Water End of Duplex Pump

What should be the diameter and stroke of pistons of a duplex pump to discharge 500 gal. per min. with a piston speed of 100 ft. per min., slippage 15 per cent and length of stroke $1\frac{1}{2}$ times the diameter of water pistons? A. W. W.

If the actual discharge of a pump is to be 500 gal. per min. and slippage is 15 per cent, then the piston displacement is $500 \div (1.00 - 0.15)$, or $500 \div 0.85 = 588.2$ gal., or $588.2 \times 231 = 135{,}874$ cu.in. per min.

Hence, if a single pump piston had an area of 1 sq.in. and piston displacement of 135,874 cu.in. per min., the piston speed would have to be 135,874 in. per min., equal to $135{,}874 \div 12 = 11{,}322.8$ ft. per min., and conversely, if the piston speed were 100 ft. per min., the piston area required for pumping the same amount of water would have to be $11{,}322.8 \div 100 = 113.228$ sq.in.

If the pump is duplex—that is, has two water cylinders—then each piston would need to have an area of $\frac{1}{2}$ of 113.228 sq.in., or 56.6 sq.in., and neglecting the reduction of area due to the piston rods, the diameter of each water piston would have to be $\sqrt{56.6} \div 0.7854 = 8\frac{1}{2}$ in. Or allowing for a 2-in. diameter piston rod, the diameter would be about $8\frac{3}{4}$ in. As the stroke is intended to be $1\frac{1}{2}$ times the diameter, the stroke would be $8\frac{3}{4} \times 1\frac{1}{2} = 13\frac{1}{8}$ in.; that is, each water cylinder would be $8\frac{3}{4} \times 13\frac{1}{8}$ in.

Starting Alternating-Current Generators and Synchronous Motors

In synchronizing motors and generators to the station bus, the power factor meters usually indicate a low-lagging power factor. Is this due to improper synchronizing or improper adjustment of the field current? Do the machines keep the phase relations they had at the instant the switch is closed, or is there a slight change afterward? W. T. L.

When starting a synchronous motor, it takes a lagging current from the line due to the machine being started as an induction motor, and therefore its magnetization must be supplied from the alternating-current circuit. After the machine has been brought up to speed and the field coils are connected to the direct-current excitation source, the magnetization can be adjusted to bring the power factor to unity, at which value all the excitation is supplied from the direct-current line.

In connecting an alternating-current generator in parallel with other machines, there are a number of combinations of voltage and speed that can be made to exist when the switch is closed on the incoming machine. If the voltage is high on the incoming machine, it will supply a lagging current to the other machines on the system when connected to the busbars. On the other hand, if the voltage of the incoming machine is low, the other machines will supply a lagging current to it. A little experimenting should show the best voltage at which to connect the machines to the bus. It is generally best to close the switch with the incoming machine running a little fast and the voltage a little high. Then the machine will pick up some load from the system when the switch is closed and tend to relieve any disturbance that might be caused in the paralleling operation. After the switch is closed, all machines must take the same phase relation and continue to retain this condition. If they all have the same number of poles, they will run at the same speed. The only difference will be in the angular position of the rotors, corresponding to the proportion of the load each machine may be carrying.

Measuring Steam Used by Jet Blower

How can a test be made of the quantity of steam used for operation of a steam-jet blower? J. R. M.

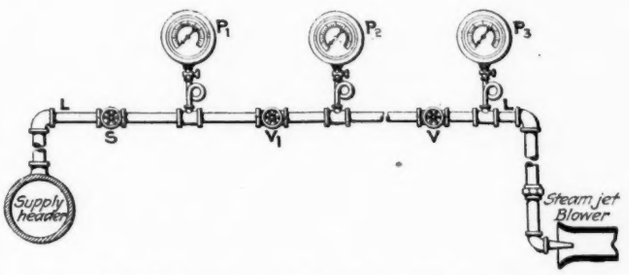
A direct test of the steam consumption can be made with an appropriate steam-flow meter placed in the supply line to the steam-jet blower; or the quantity of steam in question may be determined by establishing conditions to obtain and calibrate the same rate of flow in the supply pipe when the discharge takes place into a condenser or through an aperture to the atmosphere, as when steam is being used for operation of the blower.

The illustration diagrammatically shows a simple arrangement of stop valves and pressure gages for adjustment and observation of conditions to obtain the same flow during the calibration as when the blower is in operation; and although the test pressure may be less than the regular operating pressure, the consumption of steam in regular operation can be determined by making appropriate correction.

Assume that the blower is supplied from the steam header through the stop valve S, the supply line LL, and blower supply valve V. In consequence of the throttling action of the supply pipe and fittings the full pressure in the header never is realized at the blower. Insertion of a valve V_1 causes further reduction of the pressure, the amount depending on the adjustment of this valve.

The difference of the readings of pressure gages P_1 and P_2 will be an indication of the drop of pressure between their points of connection with the supply line, and a pressure gage P_3 placed beyond the valve V will indicate the pressure of steam supplied to the blower. Assuming that the pressure in the header is 150 lb. gage, make a test of the blower discharge for a less pressure of, say, 100 lb. Now regulate the valves S, V_1, V so that the desired discharge pressure (100 lb.) will be shown by pressure gage P_3 with P_1 indicating a pressure that can be maintained between valves S and V_1, and so there will be a decided drop in pressure, say 10 lb., shown between the P_1 and P_2 from adjustment of valve V_1.

Then without disturbing the adjustment of V_1 replace the discharge to the blower by discharging through an aperture to the atmosphere with the same pressure as before on each side of the valve V_1. This can be obtained by regulation of the main stop valve S for any change of the header pressure and by adjusting the valve V. Observe the pressure P_3. This discharge



GAGING FLOW OF STEAM TO BLOWER

which will be the same as previously through V_1 can be computed by Napier's approximate rule:

Pounds per second = absolute pressure $P_3 \times$ area of aperture in square inches $\div$ 70.

The pressure shown by gage P_3 when steam was discharged through the blower may not be the same as the regular operating pressure. For correction, multiply the computed discharge through the aperture (pounds per second) by the absolute pressure for regular operation and divide by the absolute pressure at P_3 obtained when discharge took place through the aperture.

In place of computing the flow through an aperture based on the pressure shown at P_3 and area of aperture, the flow taking place for given conditions of V_1 and pressures P_1 and P_2 may be discharged and condensed in a tank or barrel partly filled with water, and the increase of weight in a given time, due to the addition of condensate, would be the weight of steam used by the blower in the same time when operated at the pressure observed when discharge took place through the blower; and the discharges for different pressures may be assumed to be in proportion to their absolute pressures.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Advantages of Good Power Factor*

By A. R. Stevenson, Jr.†

Where the power company installs a synchronous condenser near the load center, the question arises as to what power factor is the most economical. It is impossible to make a definite statement on this subject which can be applied in all cases, because of widely varying conditions. In attempting to discuss this question, it will be divided into two parts: (1) What is the most efficient power factor? (2) What is the best power factor from the viewpoint of investments in apparatus?

The most economical power factor will be a compromise between these two conditions. If the most efficient power factor is determined and also the power factor that will give the least first cost, it seems quite certain that the most economical power factor will lie between these two.

Consider the addition of synchronous condensers to a power system for the purpose of raising power factor. The most efficient power factor will be given by the formula:

$$P.F. = \frac{1}{\sqrt{1 + \left(\frac{C}{A}\right)}} \qquad (1)$$

where C represents the losses of the synchronous condensers excluding the excitation loss expressed as a fraction of the kilovolt-ampere rating of the machine (the excitation loss of the synchronous condenser is not included because the ampere turns excitation furnished in the machine balance other ampere-turns which would have been necessary in the generators and it simplifies the problem to assume that these balance exactly); A is the total resistance loss at unity power factor and given load on the alternators, transformers and distribution system expressed as a fraction of the load in kilowatts. The losses of a 300-kva. synchronous condenser are 21 kw., but 5¼ kw. of this is the excitation. Therefore, C is 15.5 ÷ 300 or approximately 0.05.

The losses in the alternators, transformers and transmission lines are probably between 10 and 15 per cent. By substitution in (1), it is found that the most efficient power factor is as follows:

$$\text{If } C = 0.05 \text{ and } A = 0.10,\ P.F. = \frac{1}{\sqrt{1 + \left(\frac{0.05}{0.10}\right)^2}} = 0.90;$$

$$C = 0.05 \text{ and } A = 0.15,\ P.F. = \frac{1}{\sqrt{1 + \left(\frac{0.05}{0.15}\right)^2}} = 0.95.$$

From the viewpoint of lowest first cost the best power factor is given by the formula,

$$P.F. = \frac{1}{1 + \left(\frac{M}{N + P}\right)^2} \qquad (2)$$

where M = the price per kva. of the synchronous condenser; N = the price per kva. of the generating unit; and P = the price per kva. of the distribution system.

A 2,500-kva. turbo generator has a price per kva. of about $5.20. If the turbine is included, the price per kva. is about $14. It is likely that if a customer buys a larger generator, he will also buy a larger turbine, therefore let N = $14. It is also likely that the distribution system would cost at least $20 per kilovolt-ampere, therefore P = $20 and the price of the synchronous condenser will be taken at $11 per kilovolt-ampere.

Substituting these values in equation (2), the best power factor from the viewpoint of the first cost of equipment, is found to be,

$$P.F. = \frac{1}{1 + \left(\frac{11}{14 + 20}\right)^2} = 0.91$$

From the viewpoint of most efficient operation it is therefore advisable to raise the power factor to approximately 90 per cent. It has also been shown that from the viewpoint of lowest first cost the power factor should be somewhere in the neighborhood of 90 per cent.

While the losses of a 300-kva. synchronous condenser are about 21 kw., the losses of a 300-kva. static condenser are only about 1½ kw., but a static condenser of this size costs about 60 per cent more than the synchronous condenser. Static condensers need maintenance and should be installed and kept up by the power company.

When the synchronous condenser belongs to a customer, the question cannot be solved in this abstract way. The advantage derived by the power user in installing the synchronous condenser depends entirely on the bonus given by the power company for power-factor correction. This bonus must be compared with the fixed charges on the investment and the energy loss in the condenser which the customer has to pay for in his monthly power bill. In a few cases that I have investigated, the losses of a synchronous condenser and the interest on the investment for the unit seem to overbalance the bonus that the customer obtains from power-factor correction.

Synchronous Motor Suitable for Most Constant-Speed Loads

There are a great many loads that can be driven by synchronous motors. In fact, of late years the synchronous motor has been so improved in its starting and pull-in torques that there are few constant-speed loads that it is not suitable to drive. The customer can correct power factor with much less investment and smaller contingent power losses by installing synchronous motors operating at a leading power factor rather than installing synchronous condensers. Designing the synchronous motor for reactive kva. increases its cost and during operation the reactive kva. is obtained only with a corresponding drop in efficiency. Even at high speed an 0.80 power-factor motor cost at least 20 per cent more than the corresponding unity-power-factor motor and its efficiency is at least one per cent worse. At low speed the difference is much greater in both cost and efficiency.

On account of this additional expense and worse efficiency it is hard to persuade a customer to install an 0.80 power-factor synchronous motor, because the bonuses which the power companies give for power-factor correction in some cases seem to be overbalanced by the additional losses which increase the customer's energy charge and by the additional investment. There is some question as to the advisability of 0.80 power-factor motors at high speeds, but there is no doubt that it is uneconomical to purchase 0.80 power-factor motors at slow speeds. But unity power-factor synchronous motors can be built for very little more than the cost of a slip-ring induction motor and have as good or better efficiencies. At low speeds the comparison is all in favor of the unity-power-factor synchronous motor as against an induction motor.

At the same time a unity-power-factor synchronous motor will improve the customer's power factor, such a type of motor having been recently developed. The expense of installing these motors has been reduced to a minimum by simplifying the control. The exciters are adjusted for unity power factor at full load, and no field rheostats are necessary. The only control apparatus needed consists of a standard starting compensator and a standard field switch. The motors themselves being designed for unity power factor, they have good efficiency, and their price is only slightly more than that of a slip-ring induction motor. When a power user wants to improve the power factor, it is sometimes more advantageous to replace an induction motor by a unity-power-factor synchronous motor than to purchase a synchronous condenser.

With the field set at its full-load value the synchronous motor draws some leading kva. at part loads. The removal of the induction motor reduces the reactive lagging kva. The total improvement of the system obtained by replacing the induction motor with a unity-power-factor synchronous motor is the sum of the reactive kva. lagging of the induction motor and the reactive leading of the synchronous motor.

*Abstract from a paper "Power Factor Correction," read at the New England Power Engineers' Association meeting, Lynn, Mass.

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Save Coal by Burning Waste Fuels

In view of the decreasing supply and the increasing cost of high-grade fuels, the efficient utilization of fuels of low grade, including what are known as "waste fuels," is becoming a problem of major importance to many industries and to the commercial progress of the nation, states the Bureau of Mines. Important sources of "waste fuel" enumerated by David Moffat Myers, consulting engineer of the Bureau, include sawdust, shavings, scraps, edgings, tanbark, wood-extract chips, paper-mill refuse, bagasse or spent sugar cane, and city refuse.

Perhaps the most important waste fuel in the United States is spent tanbark, according to Mr. Myers. A rough estimate would indicate that this material generated a few years ago an amount of steam that would have otherwise required the yearly consumption of about 2,000,000 tons of high-grade coal. Yet at one time this valuable fuel was considered a mere detriment and an expense to the leather industry. Furnace improvements converted a substance supposedly incombustible into a valuable waste fuel, and an enormous waste was converted into an equally great saving.

Sawdust and wood waste are of course available mainly in lumbering districts. With sawdust the sawmills produce waste wood in the form of edgings, end cuts, shavings and various forms of blocks and scraps. At many plants the bulk of this material is so great that it not only supplies power and heat for the mill but also furnishes electric lighting for the whole town. Even then, in order to prevent its accumulation, a large destructor is kept constantly in operation and the heat from the burning wood is wasted to the atmosphere. If there were a market for electric power within reasonable distance, this deplorable waste could be converted readily into a great economy. Even now plans are being considered to prevent such waste and at least one plant is in operation for producing wood alcohol and other chemicals from such material. Inventors have long worked on plans that might make possible its use for wood pulp in the paper industry. Sawdust and wood waste are readily convertible into gas that may be used as fuel in gas engines.

Bagasse is the byproduct fuel resulting from the manufacture of cane sugar. The juice from the ripe cane is extracted by crushing in powerful mills. The remaining fibrous material, known as bagasse, is conveyed to the boiler house, where it is fired in special furnaces and is made to produce all or part of the steam required to operate the plant. The fuel is in the form of strips 3 to 8 in. long, but much longer pieces may sometimes come through the mills. The Bureau of Mines considers that there is much room for improvement in the design and in the control of furnaces in many plants burning bagasse; these two factors often make the difference between running the boiler plant on very little or no purchased fuel and of spending large sums annually for coal, oil, or wood.

When gas is made by the destructive distillation of soft coal, which is the older method employed at city gas works, a finely divided coke known as coke breeze is left as one of the important byproducts. As the volatile gases have been driven off, the coke is mainly carbon, which is naturally higher in ash than the coal. The particles of coke are about the size of No. 2 or No. 3 buckwheat coal and may be used successfully as a boiler fuel with proper furnace equipment. Coke breeze may compete with the fine sizes of low-priced anthracite.

City refuse belongs to the class of fuels that, by proper application of the principles of combustion have been promoted from semi-combustible to autocombustible fuel. Though this heterogeneous material may be disposed of by dumping at sea or on waste land—sometimes in an inexpensive manner— the consensus of opinion is strongly in favor of its disposition by burning. The strength of this opinion is largely due to comparatively recent improvements made in the design and efficiency of destructors or refuse burners. Furthermore, when combustion is complete, burning is by far the most sanitary method of disposing of offensive materials.

It is a notable achievement of engineering study and skill that has made possible not only the smokeless and complete combustion of city refuse, but also the production of useful heat and power from this former waste. Some of the collected matter, chiefly the house garbage, contains so much moisture in comparison with its low heating value that to burn it alone would be impossible, but by mixing this with all the other refuse, the calorific value of the mass is made high enough not only to evaporate its contained moisture, but to produce effective evaporation in a boiler as well. Even when this is done, however, it is necessary to depend for efficiency on correct design and careful operation of the furnace.

The results of a special study of the economic combustion of waste fuels are contained in Technical Paper 279, which may be obtained from the Bureau of Mines, Washington, D. C.

Coal for Pine Grove Plant Will Be Hauled Only Four Miles

Two 12,500-kw. 12,000-volt generators will form the initial installation in the East Penn Electric Co.'s new plant at Pine Grove, Pa., to be completed in June or July. This station is laid out for 50,000-kw. extensions, with the boiler aisles at right angles to the turbine hall, permitting the use of larger turbines and of powdered coal in future extensions.

Anthracite "fines" of 11,500 B.t.u. and 20 to 25 per cent ash will be received from a mine only four miles away, at a price so low that the designers have decided against the use of economizers. With a cooling pond and a regulating reservoir to conserve the flow of Swatara Creek, on which the plant is built, sufficient circulating water will be obtainable for a 300,000-kw. development, according to J. G. White Engineering Corp., designers of the plant.

Among the features of the new plant are its sectional development and extreme simplicity, the use of extra long (18-ft.) forced-draft traveling-grate stokers capable of operating at 300 per cent of boiler rating, and the method of horizontally sectionalizing the furnace-wall facing by interlocking tile courses, each of which supports only six courses of firebrick. This relieves the pressure on the furnace firebrick and facilitates replacement of sections. Although the boilers have only 8,000 sq.ft. of heating surface per unit, larger boilers may be used in the next extension, as wider stokers will then be available. The boilers are designed for 300 lb. pressure and 600 deg. to 650 deg. total temperature. They are twenty tubes high, with the superheater placed above the sixth row. The entire length of the lower six rows of tubes is exposed to the radiant heat of the furnace.

Reports 15 Per Cent Coal Saving Through Use of Steam Jets

As the result of the simple expedient of installing two steam jets in the front of each boiler to produce agitation, with a jet and a small damper under the grates, the Bureau of Engraving and Printing of the Treasury Department has reported a saving of coal estimated at twelve tons a day. While this saving may not be maintained the year around, because of the seasonal differences in load, Edward P. Genger, superintendent of the engineering and machine division of the Bureau, who assumed this position last April and under whose direction the changes were made, estimates an annual reduction in coal consumption of upward of 2,000 tons.

One effect of installing steam jets at the plant has been a marked reduction in the number of grate bars burned out. Formerly, this ran at the excessive rate of twenty-five to forty a week. In the three months that the jets have been used, a total of sixty-nine bars have been burned out.

The Bureau's steam plant uses bituminous coal. Last year in December it was consuming an average of eighty tons daily in the main and auxiliary plants. This year, the highest consumption on any day, in the single plant operated, has been sixty-two tons. Some of this difference, however, is attributed to comparatively mild weather, which has lessened the load on the heating plant so that the actual saving in fuel effected by the changes at the plant is estimated at twelve tons daily.

News in the Field of Power

What Colorado Compact Means

Expect Ratification of Agreement Between Seven States and Federal Government

THERE is every reason to believe that each one of the seven states that are parties to the Colorado River compact will ratify that unique peace treaty at the close of their present legislative sessions. At the same time it is recognized that it lies with the power of any one of the seven states to delay the ratification of this compact and leave the road open for litigation with the resultant blockade for a generation at least of this great national asset.

Ratification of the compact means: (1) Elimination of litigation, thus removing a blockade on the development of 242,000 sq. mi., a territory larger than Republic of France. (2) Orderly development through irrigation and cultivation of 4,000,000 acres of land, now desert. (3) Utilization, as economic conditions warrant, of waste waters in the generation of over 6,000,000 hp. (4) Construction of dams urgently needed for the control of floods annually threatening the Imperial and Palo Verde Valleys in California and the Yuma project in Arizona—communities assessed at over $100,000,000, where 75,000 to 100,000 Americans gain their living. (5) New homes for 3,000,000 American citizens, including ex-service men and women. (6) New communities which will furnish increased markets for the whole country.

The details of the compact were published in *Power* for Dec. 5, 1922, on page 901. Adequately protecting the interests of all the states and of the federal government, the agreement is a historic step in interstate relations, as this is the first time that more than two states have availed themselves of the constitutional privilege of settling their differences by negotiation and compact. Similar disputes between two states relative to small tributaries have taken years when submitted to the courts for settlement. An example is the case of Wyoming vs. Colorado, decided by the United States Supreme Court on June 5, 1922, after eleven years of argument.

Uncle Sam Wants More M.E.'s and E.E.'s

Opportunities for mechanical and electrical engineers in the civil service are seen in the announcement of a series of United States Civil Service examinations, for which the receipt of applications will close on Feb. 6. Examinations will not be held at any specified time or place; instead, candidates will be rated on their education, training and experience, as indicated in their applications.

Applicants who successfully pass the examination for mechanical or electrical engineer will receive from $3,000 to $5,000 a year; associate mechanical or electrical engineers will draw $2,500 to $3,000 a year, while assistant mechanical or electrical engineers will be paid from $2,000 to $2,500.

The vacancies to be filled are chiefly in the Chemical Warfare Service, Edgewood Arsenal, Md., and in ordnance work, although there are other positions requiring similar qualifications, at the same or higher or lower salaries, that will be filled from these examinations.

Those interested should apply for Form 1312, stating the title of the examination desired, to the Civil Service Commission, Washington, D. C.

Express Need for National Hydraulic Laboratory

Hearty support for a National Hydraulic Laboratory is coming from engineers in all parts of the country, the Senate subcommittee was told during the course of a hearing on Jan. 10 at which Senator Ransdell's bill providing for the establishment of a National Hydraulic Laboratory was considered. The principal testimony was given by John Lyle Harrington, of Kansas City, president of the American Society of Mechanical Engineers; Gardiner S. Williams, of Detroit, a hydraulic engineer, and John C. Ralston, of Spokane, Wash., a civil engineer.

The subcommittee was told that all branches of engineering are coming to attach greatly increased importance to research. The hydraulic laboratory would do much to supplant rough and ready knowledge of hydraulic formulas and practice with exact knowledge, it was said. Mr. Harrington cited a number of cases in which there have been wide divergence of engineering opinion on fundamental problems in hydraulics. In each case the completion of the work demonstrated absolutely that certain theories advanced by eminent engineers were wrong. These differences never would have arisen had accurate, basic information been available.

The Refractories Manufacturers Association, 840 Oliver Building, Pittsburgh, Pa., has published the fourth edition of a booklet entitled "Brands of Firebrick and Other Refractories," which lists the trade names used by practically all the manufacturers of refractory brick. The booklet is useful to the man who wants the maker's name of a particular brand of firebrick. Copies are furnished gratis by the association.

Plan Engineering Congress

Meeting in Philadelphia in 1926 Will Promote World Union of Engineers

PLANS for an International Engineering Congress to be held in 1926, at the time of the Sesqui-Centennial Exposition in Philadelphia, were made at a conference in New York City, on Jan. 9, of some twenty-five or thirty leading engineers from the different engineering organizations. The meeting was called to order by the Committee on Plan and Scope, with Richard L. Humphrey presiding. Discussion took place under the following general headings: Scope of the congress, finance, relation of meetings of engineering societies to the sessions of such a congress, and publicity.

It was brought out that the meeting represented another step toward bringing the engineers of the different countries closer together, taking up the threads of contact broken by the war and fostering a better understanding of the relation of the engineer not only to the technical problems of the world but to the reconstruction of our present-day civilization, to which the engineer has already contributed so much. That the program of the world congress should consist of papers stressing the broader relations of the engineer to the public, rather than of a large number of technical papers, was emphasized.

The movement to hold a world congress of engineers was started in 1921 by the Engineers Club of Philadelphia. An invitation was extended to the four founder societies and to the American Society for Testing Materials, each being requested to appoint two representatives to meet with a committee of the Engineers Club of Philadelphia. The following representatives were appointed:

American Society of Civil Engineers—George S. Webster, Richard L. Humphrey.
American Institute of Mining and Metallurgical Engineers—J. Vipond Davies, Charles F. Rand.
American Society of Mechanical Engineers—James Hartness, D. Robert Yarnall.
American Institute of Electrical Engineers—Arthur E. Kennelly, Charles E. Skinner.
Federated American Engineering Societies—J. Parke Channing, L. P. Alford.
The Engineers' Club of Philadelphia—W. C. L. Eglin, Charles E. Billin.

The board of management later organized and elected George S. Webster, temporary chairman, and Charles E. Billin, temporary secretary, and appointed the following committees:

Nominating committee—J. Vipond Davies, Chairman, L. P. Alford, Richard L. Humphrey.
Committee on Plan and Scope—Richard L. Humphrey, Chairman, Charles F. Rand, James Hartness, Arthur E. Kennelly, J. Parke Channing, W. C. L. Eglin.
Committee on Participation—E. Robert Yarnall, Charles E. Skinner, Charles E. Billin.

F.A.E.S. Meets in Washington

Noted Speakers at First Session of Engineering Council's Annual Meeting

OUR engineering relations with foreign countries, with special reference to the work done by Calvin W. Rice during his recent visit to South America, and to the possibility of holding an engineering congress in China, formed the chief topic of President Mortimer E. Cooley's address at the opening session of the annual meeting of the American Engineering Council, Federated American Engineering Societies, in Washington, on Jan. 11.

Reforestation and transportation were suggested as fields to which the Federation might well extend its activities. Mention also was made of a new investigation comparable with that on industrial waste, and for which $30,000 may be made available. A motion to allow the affiliation of foreign engineering societies with the F.A.E.S. was laid on the table. A long discussion on the report of the publicity committee, which dealt with the bulletin now being published and with the question of advertisements, ended in the adoption of a resolution to refer the whole question to the executive board.

The report of the committee on business cycles, recommending that the Department of Commerce issue more reports on economic facts and fewer forecasts on business conditions, was adopted as revised by Secretary Hoover. The question of an adequate and permanent staff for the Federal Power Commission received consideration. A budget of some $45,000 for the coming year was recommended by the finance committee. The constitution was revised to provide for an alternate member on the Council and to permit such duly accredited alternate member to act with full power on the executive board.

The secretary's report reviewed the year's activities, referring particularly to reforestation, waste in industry, the eight-hour versus twelve-hour shift, the appointment of a committee of engineers to consider the Muscle Shoals problem, the appointment of engineers on the Coal Commission, the bill for a National Hydraulic Laboratory, etc.

Dean M. E. Cooley was re-elected president; Calvert Townley, Philip N. Moore and Gardner S. Williams were elected vice-presidents and H. E. Howe was made treasurer.

At the dinner at the Chevy Chase Club, to welcome Prince Celasio Gaetani, Italian ambassador, the principal speakers were: John James Tigert, United States Commissioner of Education, Calvin W. Rice, Elmer N. Sperry and Prince Gaetani.

Engineering Employment for 1922 Reviewed by A.A.E.

That engineering employment "grew better and better" every month during the last year is reported by the employment department of the American Association of Engineers. For 1923, says the report, there is every indication that a big shortage of technical men will be experienced, especially during the first few months.

Already the demand for designers on all classes of work is far above the supply, with a larger demand certain as new work is started. Construction specialists, particularly on buildings, hydro-electric and drainage projects, will be wanted. A healthy demand may be expected for engineers in manufacturing and specialists on design. The electrical field will be rather dull and advancement may be expected only by those who specialize in certain phases or who develop their abilities in more commercial work.

Salaries for the last year have been on a gradual increase in the more basic positions. The average salary, however, as compared with the cost of living, is still below a just figure for professional work. The few decreases in salaries noted are in the county and municipal fields, in industrial and manufacturing work and in some railroad positions. Increases in salaries in these fields during 1923 may be expected. The average salary for graduates was considerably more last year than the average before the war. In 1914 the graduate was receiving from $60 to $75 a month, while last year's graduates are paid on an average of $125 a month.

Georgia Company To Expand During 1923

An increase of 300,000 hp. in the hydro-electric capacity of the Georgia Railway & Power Co. is planned for 1923. The Mathis-Tallulah development, costing around $1,000,000, is the largest single item on the program. A tunnel one mile long, cut through a mountain connecting the Mathis and Tallulah reservoirs, will eliminate a bend of five miles in the Tallulah River. This tunnel will feed into the new Mathis power house.

Having a capacity of 22,000 hp. and operating under a head of 190 ft., the Mathis power house will be of the automatic remote-controlled type, handled entirely from the Tallulah plant. The power from the Tugaloo, Mathis and Tallulah plants will be controlled from a switching station to be installed at Tallulah. This will mean continuous service, as the power from all the plants may be switched onto any of the main lines as needed.

The second big feature will be the completion of the new Tugaloo dam and power plant by Jan. 1, 1924. This plant will develop 88,000 hp., increasing the company's output about 50 per cent. A third improvement will be a 50 per cent increase in the capacity of the Morgan Falls plant, twenty miles from Atlanta.

The completion of the new power plants and the installation of the proposed switching station will give ample reserve power for all northern Georgia and will greatly improve the company's service. More than $6,500,000 will be spent, with $3,000,000 assigned to Atlanta alone.

More Power for Twin Cities

Ten-Year Steam-and Water-Power Development Program Will Add 306,000 Hp.

A NEW water- and steam-power construction program for the cities of Minneapolis and St. Paul, involving an estimated expenditure of $80,000,000, has been announced. The new construction will take about ten years and will increase by 306,000 hp. the capacity of the Northern States Power Co., a subsidiary of the Standard Gas and Electric Co.

Work will start at once on the construction of a large steam plant in St. Paul, for which about forty acres have been acquired on the Mississippi River near the High Bridge. A 40,000-hp. turbo-generator will form the initial unit, to be followed immediately by 60,000 hp. additional capacity. During the ten-year period additional generating capacity of about 100,000 hp. will be added to the new power plant in St. Paul and to the Riverside station in Minneapolis, which now has a total capacity of 103,000 hp.

The Federal Power Commission has authorized the Northern States Power Co. to proceed with the development of the St. Croix and upper Mississippi rivers, and 106,000 water horsepower will be added by the construction of the following projects: 27,000 hp. at the Nevers Dam site, eleven miles above the present St. Croix (Taylor's) Falls hydro-electric plant; 33,000 hp. at Kettle River Rapids, twenty-eight miles north of Nevers Dam; 10,000 hp. at St. Croix Falls; 20,000 hp. at Otsego, and 16,000 hp. at Monticello.

A third dam will be built in the St. Croix River, eight miles above Kettle River Rapids. To distribute the additional power, a new transmission loop will be built around the Twin Cities. The Byllesby Engineering and Management Corporation will handle the new construction.

New York State Amends Its Water-Power Plea

The motion of the State of New York for leave to amend its bill of complaint in the suit to test the validity of the Federal Water-Power Act and to restrain the Federal Power Commission from exercising jurisdiction over certain waterways in New York has been granted by the Supreme Court.

In its amended petition the state contends that its ownership rights are challenged and that the Federal Power Commission is attempting to regulate waterways that do not affect navigation, thus going beyond the regulation and control of waterways for the specific purpose of navigation, which the state claims is the proper interpretation of the Water Power Act and the only authority that may be exercised properly by the Federal Power Commission. The state anticipates a multiplicity of lawsuits and resents being deprived of its constitutional rights to handle affairs within its own boundaries when these do not affect other commonwealths.

Water-Power Projects

The Washington Water Power Co. is now in a position to go ahead with the first step in its development at Kettle Falls. Work is to begin this year on a 35-ft. dam across the smaller channel at the Falls. It is estimated that the dam will cost $3,000,000. It will develop some 30,000 hp.

The International Joint Commission will hold a hearing in New York on February 12 at which it will take testimony in regard to the application of the **New York-Ontario Power Co.**, which has asked for a right covering a certain amount of water through the south channel of the St. Lawrence at Waddington, N. Y. The power company has applied to the Federal Power Commission for a preliminary permit covering this proposed utilization of water, but, as in the case of other St. Lawrence applications, it is being held to await the settlement of the whole St. Lawrence matter.

Personal Mention

E. C. Brandt, works manager of the Westinghouse-Krantz Works, has been appointed works manager of the new Westinghouse plant now being erected in Homewood, Pittsburgh, Pa.

Robert Sibley, for several years editor and more recently editorial director of the *Journal of Electricity and Western Industry* and Pacific Coast editorial director of *Electrical World* and *Electrical Merchandising*, has left the McGraw-Hill Co., Inc., to become associated in an executive capacity with University of California alumni work. Mr. Sibley will, however, retain a consulting interest in the McGraw-Hill papers.

Society Affairs

An illustrated talk by Calvin W. Rice, secretary of the A.S.M.E., on "The Engineering Societies of South America," will be given before various local sections of the society, as follows:

Waterbury Branch, Jan. 16; **Schenectady Branch**, Jan. 17; **Philadelphia Section**, Jan. 23. **Meriden Branch**, Jan. 25, and **New Britain Branch**, Jan. 26.

Worcester Section, A.I.E.E., will meet on Jan. 18 to hear a talk by S. C. Moore on "The New England Power System."

Pittsfield Section, A.I.E.E., will meet on Jan. 18. J. L. Harper will talk on "Power Development at Niagara."

Metropolitan Section, A.S.M.E., will consider "High-Temperature Alloys" at its meeting on Jan. 23 in Newark, N. J.

Bridgeport Branch, A.S.M.E., will meet Jan. 18 at the Stratfield Hotel, to consider "Composition of Matter—The Electron." Mr. Davies, of the General Electric Co., will speak.

New Haven Section, A.S.M.E., will hold its "Fuels for Industry" meeting at Mason Laboratory, Yale University, on Jan. 22, instead of on Jan. 15 as previously announced. J. A. Doyle, of W. S. Rockwell Co., will speak on "Heating Processes."

Virginia Section, A.S.M.E., will hold a joint meeting with the A.S.C.E., A.I.E.E. and A.A.E. at the Chamber of Commerce, Richmond, Jan. 22-23. Ten speakers will consider such topics as "Municipal Engineering," "Street Lighting and Paving," "Construction Equipment," etc.

Business Notes

The Sanford Riley Stoker Co. has acquired control of the Ground Coal Engineering Co., Chicago, designer and builder of pulverized-fuel installations. Incorporated in Massachusetts, the Ground Coal company will have its headquarters at Worcester. R. Sanford Riley is president and M. W. Arrowood vice-president. The company holds patents on the burning of pulverized coal by the Arrowood "multi-mix" burners. The Underfeed Stoker Co. of Canada, Ltd., Toronto, will handle the Canadian territory. The headquarters of William Pestell, sales manager of the Sanford Riley Stoker Co., have been transferred from New York City to Worcester, Mass. The New York office will be retained at 103 Park Ave.

The Combustion Engineering Corp., 43 Broad St., New York City, has acquired control of the Quinn Oil Burner and Torch Co., whose president, W. R. Quinn, becomes manager of the Combustion corporation's fuel oil department.

The Uehling Instrument Co., Paterson, N. J., has appointed the Mine & Smelter Supply Co., El Paso, Tex., as its sales representative in Arizona, New Mexico and western Texas as well as in the Republic of Mexico, north of Mexico City.

Coming Conventions

Marine Engineers' Beneficial Association; George A. Grubb, secretary, Machinists' Bldg., 9th St. and Mount Vernon Place, Washington, D. C. Annual meeting at Washington, Jan. 15-20.

American Society of Civil Engineers, 29 W. 39th St., New York City. Annual meeting at New York City, Jan. 17-18.

Iowa Engineering Society; Lloyd A. Canfield, secretary, 406 Flynn Bldg., Des Moines. Annual meeting at Des Moines, Jan. 23-26.

American Society of Heating and Ventilating Engineers, 29 West 39th St., New York City. Annual meeting: Jan. 23 at New York City, Jan. 24-26 at Washington, D. C.

American Boiler Manufacturers' Association; H. N. Covell, 191 Dikeman St., Brooklyn, N. Y. Winter meeting at New York City, Feb. 12.

American Institute of Electrical Engineers, 29 West 39th St., New York City. Mid-winter convention at New York City, Feb. 14-16.

American Institute of Mining and Metallurgical Engineers, 29 West 39th St., New York City. Annual meeting at New York City, Feb. 19-21.

Trade Catalogs

Motors, Heavy-Duty—The Louis Allis Co., Milwaukee, Wis. Bulletin No. 406, describing the characteristics and features of construction of the L-A Type H. D. heavy-duty motor.

"Storing Coal Safely"—The Protectometer Co., 154 Ogden Ave., Jersey City, N. J. Describes the Fedco Protectometer system of indicating temperature in coal piles and of guarding against overheating.

"Plant and Products" — De Laval Steam Turbine Co., Trenton, N. J. Catalog T, a 24-page booklet briefly describing the company's entire line of products, including single and multi-stage steam turbines, centrifugal pumps, blowers and compressors, and speed-reducing gears.

Harrington Stoker—United Machine & Manufacturing Co., Canton, Ohio. An exceptionally well-gotten-up catalog of the Harrington stoker, adapted to the burning of finely divided as well as coarse fuels. The non-sifting character of the grate permits the burning of coke breeze, coking bituminous, free-burning bituminous, lignite and all sizes and characters of anthracites, including river dredgings.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	Dec. 26, 1922	Jan. 8, 1923
Pool 1,	New York	$6.00–6.50	6.00–6.75
Smokeless,	Columbus	5.75–6.25	6.50–6.75
Clearfield,	Boston	3.75–4.75	4.75–5.50
Somerset,	Boston	4.00–4.85	5.00–5.75
Kanawha,	Columbus	3.00–3.25	3.50–4.00
Hocking,	Columbus	2.75–3.00	3.00–3.25
Pittsburgh No. 8	Cleveland	3.20–3.35	3.40–3.65
Franklin, Ill.,	Chicago	4.00–4.25	4.00–4.25
Central, Ill.,	Chicago	3.00–3.25	3.25–3.75
Ind. 4th Vein,	Chicago	3.75–4.00	3.75–4.00
West Ky.,	Louisville	3.25–3.50	2.50–3.00
S. & E. Ky,	Louisville	3.25–3.75	3.50–4.00
Big Seam,	Birmingham	2.50–2.75	2.50

FUEL OIL

New York—Jan. 11, Port Arthur light oil, 22@25 deg. Baumé, 4¼c. per gal.; 30@35 deg., 5¼c. per gal., f.o.b. Bayonne, N. J.

Chicago—Dec. 16, for 24@26 deg. Baumé, 90c. per bbl.; 32@36 deg., 2¾@3c. per gal. in tank car, f.o.b. Oklahoma refinery, or freight adjusted.

Philadelphia—Jan. 8, 26@28 deg. Baumé, Oklahoma, 90@95c. per bbl.; 30@34 deg., Oklahoma (group 3), 2⅝@2¾c. per gal.; 16@20 deg. Seaboard, $1.30@$1.40 per bbl.

St. Louis—Jan. 8, f.o.b., Oklahoma, 24@26 deg., 95c. per bbl.; 26@28 deg., $1 per bbl.; 28@30 deg., $1.05 per bbl.; Gas oil 32@36 deg., 3c. per gal.; 36@40 deg., distillate, 3½c. per gal.

Pittsburgh—Dec. 27, f.o.b., refinery, Penn., 36@40 deg., 5½@5¾c. per gal.; Kentucky, 26@30 deg., 4c.; Diesel, 3½c.; Gas oil, 32@36 deg., 2½@2¾c.; 36@38 deg., 2½@3c.; 38@40 deg., 90c.@$1.05 per bbl.

Dallas—Jan. 11, 26@30 deg., $1.28 per bbl.

New Plant Construction

POWER PROPOSED

Calif., Hanford — The Hardwick School Dist., L. Landis, Clk., will receive bids until Jan. 18, for the construction of a hydro-pneumatic water supply system, including the furnishing and installing 10 x 36 in. tank, 525 gal. capacity, with manhole and guaranteed 100 lb. working pressure with pump capable of supplying approximately 1,000 gal. per hour, together with suction and discharge pipes, fittings, etc.

Calif., Oakland — The Franklin Theatre Co., c/o Weeks & Day, Archts., Calif. Insurance Bldg., is having preliminary plans prepared for the construction of a theatre and hotel building on Bway. and Grand Ave. Estimated cost $350,000. Equipment detail not reported.

Calif., San Diego—The Pacific Telephone & Telegraph Co., 1130 6th St., A. E. Scott, Local Mgr., plans enlarging and extending its system, including about 38,000 ft. of underground cable and 220,000 ft. aerial cable of various capacities from 25 to 1200 pairs, additional sections of switchboards will be installed in main and branch stations. Estimated cost $500,000.

Calif., Santa Barbara—E. A. Johnson, c/o A. B. Rosenthal, Archt., Orpheum Bldg., Los Angeles, is having plans prepared for the construction of an 8 story office and theatre building. Estimated cost $500,000. Equipment detail not reported.

Calif., Santa Rosa—County of Sonoma, W. W. Felt, Jr., Clk., plans to levy tax to finance the construction of a county hospital. Estimated cost $250,000.

Calif., Santa Rosa — Dunn-Hurst & Martin, Insurance Exchange Bldg., San Francisco, representing owners, plans the construction of a 6 story hotel and apartment building. Estimated cost $500,000. Architect not selected.

Ill., Chicago—Freyn, Brassert & Co., Engrs., 122 South Michigan Ave., are in the market for 2 vertical crosshead high pressure blowing engines.

Ill., Shelbyville—The city council will receive bids until Feb. 5 for the installation of a complete electric light and power plant. W. A. Fuller Co., Railway Exchange Bldg., St. Louis, Mo., Consult. Engr. Noted Dec. 19, 1922.

Ind., Indianapolis—The Bd. Educ. plans the construction of a west side high school and a colored high school, each 2 stories. Estimated cost $500,000 each. Architect not selected.

Ind., Indianapolis—The Monument Place Bldg. Corp., c/o Vounegut, Bohn & Mueller, Archts., Indiana Trust Bldg., plans the construction of a 14 story office building on North Meridian St. Estimated cost $1,000,000.

Ind., Indianapolis — E. G. Spink, 914 Hume-Mansur Bldg., is receiving bids for the construction of an 8 story, 54 x 170 ft. apartment hotel including steam heating system and incinerators, on North Meridian St.; also plans a 9 story, 67 x 130 ft. office building on East Michigan St. Estimated cost $500,000 and $875,000 respectively. W. K. Eldridge, Hume-Mansur Bldg., Archt.

Ind., Indianapolis — The Terra Haute, Indiana & Eastern Traction Co., Traction Terminal, plans to purchase and install, two 31,250 kw. turbo generators with necessary condensing apparatus and switchboard facilities, in its power plant on West 10th St.

Ind., Indianapolis—H. H. Woodsmall, Fidelity Trust Bldg., is having revised plans prepared for the construction of a 3 story apartment building, including steam heating system, on 3847 North Meridian St. Estimated cost $600,000. D. Graham, Hume-Mansur Bldg., Archt.

La., DeQuincy—The city plans to issue $120,000 bonds to be used for the construction of new electric power and water works plants. Engineer not announced.

La., Marrero — The Celotex Co., 636 Common St., New Orleans, is having plans prepared and will receive bids latter part of Jan., for the construction of 2 additional units to its plant, here. Estimated cost $100,000. Equipment will include boilers, generators, motors, pumps, coolers, refiners, automatic saws, etc., also water purification plant. Estimated total cost $750,000. J. H. Burt, Consult. engr.

Md., Annapolis—The Bureau of Yards & Docks, L. E. Gregory, Chf., Navy Dept., Wash., D. C., will receive bids until Jan. 24, for the construction of an 89 x 289 ft. natatorium building, including steam heating and ventilating systems, here. Estimated cost $450,000. Motor driven centrifugal pump and coagulant devices will be installed. Private plans.

Mass., Boston—The Home Savings Bank, 75 Tremont St., plans the construction of a bank and office building. Estimated cost $2,000,000. Architect not selected.

Mich., Detroit—M. H. Finkel, Archt., 919 Majestic Bldg., is receiving bids for the construction of an 11 story apartment building, including vapor steam heating equipment, on Putnam and Cass Aves. Estimated cost $500,000. Noted Dec. 7.

Mass., Erving—The town has had tentative sketches made for the construction of new water system, including reservoir, mains and possibly pumping station. Estimated cost $75,000. A. F. D. Avery, 288 Main St., Greenfield, Engr.

Mich., Highland Park — The Hamilton Land Co., c/o J. P. Jogerst, Archt., 1951 Ford Bldg., Detroit, plans the construction of a 16 story, 105 x 212 ft. apartment building, including steam heating boiler and accessories and electrical equipment etc. Estimated cost $2,500,000.

Mich., Mottville—The Michigan Gas & Elec. Co., P. Simmons, Mgr., Three Rivers, is having plans prepared for the construction of a 30 x 60 x 140 ft. hydro-electric plant, 2,200 kva. capacity, on the St. Joseph River, here, including four 550 hp. hydro electric turbines, 4 waterwheels, water levee, dam 11 ft. 6 in. high, 250 ft. long with flood gates on crest. Estimated cost $400,000. Holland, Ackerman & Holland, 53 West Jackson St., Chicago, Ill., Engrs. Noted Dec. 7.

Mich., St. Joseph—Cahill & Douglas, Engrs., 217 West Water St., Milwaukee, Wis., is receiving bids for 2 water tube power boilers, for Hotel Whitcomb, here.

Minn., Minneapolis—The Northern States Power Co., R. F. Pack, Vice.-Pres. and Gen. Mgr., 15 South 5th St., plans a construction and development program to cover a period of 10 years and will increase electric generating capacity by 306,000 hp. Work will start at once on the construction of a large steam turbine generating station in St. Paul, the first generating unit to be installed will be 40,000 hp. capacity, 60,000 hp. additional capacity will be installed after 1st unit is completed. Later additional steam generating capacity of about 200,000 hp. will be added, 100,000 to Riverside Station, here, and 100,000 hp. to the new power plant in St. Paul. The Federal Water Power Comn. has authorized Northern States Power Co., to proceed with development of the power resources of the St. Croix and upper Mississippi Rivers and 106,000 hp. of additional hydro-electrical energy will be added by the construction of the following water powers: St. Croix River, Nevers Dam site, 11 mi. above present St. Croix (Taylors) Falls hydro-electric plant 27,000 hp., Kettle River Rapids, 28 mi. north of Nevers Dam, 33,000 hp., St. Croix (Taylors) Falls, to increase capacity, 10,000 hp.; Mississippi River, Otsego, 20,000 hp., Monticello, 16,000 hp., total 106,000 hp. A water storage dam also will be built in the St. Croix River 8 mi. above Kettle River Rapids. In order to distribute the additional power, a new power transmission loop will be built around the Twin Cities with necessary substations and other equipment. Byllesby Engr. & Management Corp., 208 South La Salle St., Chicago, Ill., Engrs.

Mo., Kansas City—H. B. Schoefield, 412 Scarrett Bldg., will receive bids about Feb. 1 for the construction of a 12 story store and market building on 23rd and Grand Sts. Estimated cost $2,000,000. W. S. Fergerson & Co., 1900 Euclid Ave., Cleveland, O., Archts. Equipment detail not reported.

Mo., St. Louis—Graham, Anderson, Probst & White, Archts., 80 East Jackson Blvd., is receiving bids for the construction of a 6 story hospital, including steam heating system, on Forest Park Blvd. and Kings Highway, for the Jewish Hospital Bd., 5414 Delman Blvd. Estimated cost $800,000. Noted May 23, 1921.

Mo., St. Louis—E. R. Smith, 2624 Montgomery St., is in the market for a 15 to 25 hp. upright boiler (used).

Neb., Omaha—S. Joslyn, c/o J. & A. McDonald, 204 Standard Oil Bldg., is having plans prepared for the construction of a 2 story, 180 x 430 ft. art museum at 22 Dodge St. Estimated cost $3,000,000. Equipment detail not reported.

N. J., Overbrook (Verona P. O.)—Essex County is having plans prepared for the construction of a 2 and 3 story, 400 bed hospital. Estimated cost $1,000,000. Sutton & Sutton, 401 Broad St., Newark, Archts. Equipment detail not reported.

N. J., Trenton—A. C. Bossom, Archt., 680 5th Ave., Jersey City, will receive bids until Mar. 15 for a 14 story, 66 x 149 ft. bank on West State St., for the Trenton Trust Co., State St. and Chancery Lane. Estimated cost $800,000. Equipment detail not reported.

N. Y., Buffalo—The Nichols School, Amherst and Colvin Sts., plans the construction of a school consisting of 3 buildings, including dining hall, study hall, offices, etc., also a central heating plant. Estimated cost $175,000. Architect not selected.

N. Y., New York—A. L. Erlanger, 214 West 42nd St., is having plans prepared for the construction of a 2 story, 90 x 125 ft. theatre building at 246 West 44th St. Estimated cost $500,000. Warren & Wetmore, 16 East 47th St., Archts. Equipment detail not reported.

N. Y., New York—S. Hoseff & Son, c/o R. T. Lyons, Archt. and Engr., 342 Madison Ave., is having plans prepared for the construction of a 14 story apartment building on Cathedral Pkway. Estimated cost $1,000,000. Equipment detail not reported.

N. Y., New York—The H. W. Johns-Mansville Co. Inc., 41st St. and Madison Ave., plans the construction of a 16 story, addition to office building. Ludlow & Peabody, 101 Park Ave., Archts.

N. Y., New York — P. Meirowitz, c/o Sommerfeld & Steckler, Archts., 31 Union Sq., is having plans prepared for the construction of a 14 story, 75 x 100 ft. hotel at 111 West 46th St. Estimated cost $700,000. Equipment detail not reported.

N. Y., Niagara Falls—The Chamber of Commerce, Masonic Temple, is having preliminary plans prepared for the construction of an 11 story hotel on 1st St. Estimated cost $1,000,000. Esenwein & Johnson, Ellicott Sq. Bldg., Buffalo, Archts.

N. Y., Oswego — The Netherlands Co. Inc., plans the construction of a cold storage and milk pasteurization plant. Estimated cost $250,000.

N. Y., Syracuse—The city plans the construction of a hospital on Teall Ave. Estimated cost $400,000. Engineer not selected.

N. Y., Syracuse—St. Joseph's Hospital plans the construction of a 5 story, 100 x 275 ft. hospital, also a power house and laundry building, on Prospect Ave. Estimated cost $50,000. Architect not selected.

N. C., Raleigh—The Carolina Power & Light Co., P. A. Tillery, Gen. Mgr., plans the construction of 60,000 volt substation near the State Hospital here. Condemnation proceedings are now being instituted for the site. Noted Dec. 12, 1922.

Ohio, Cleveland—The Hollenden Hotel Co., c/o J. Thompson, Mgr., East 6th St., and Superior Ave., plans the construction of a 10 or 12 story addition to hotel. Estimated cost $2,900,000. Architect not announced.

Okla., Tipton—The Tipton Power & Light Co., is in the market for one 50 or 60 kva., 2,300 volt 3 phase, 60 cycle alternator, pedestal bearing type, speed 300 r.p.m. with exciter, also 1 for 600 or 900.

Pa., Beaver—Beaver College is having competitive sketches prepared for group of college buildings on Dutch Ridge Rd. Estimated cost $1,250,000. Architect not selected. Noted Oct. 10.

Pa., Blossburg—Gannett, Sealy & Fleming, Wellsboro, is in the market for complete machinery and equipment for $150,000 power plant here.

Pa., Lebanon—The Keystone Macaroni Co., 8th St., is in the market for steam operated power plant equipment.

Pa., Lemoyne—The West Shore Lumber Co., plans the construction of a power house. Estimated cost $25,000. Owner is in the market for complete power plant equipment.

Pa., Meyersdale—The Meyersdale Electric Light, Heat & Power Co., F. L. Wilmoth, Mgr., will soon receive bids for addition to power plant and installation of 150 hp. boiler.

Pa., Phila.—The Philadelphia Elec. Co., 10th and Chestnut Sts., M. B. McCall in charge, plans addition to electric power plant, including three 30,000 kva. units on Beach and Palmer Sts. Estimated cost $6,500,000 to $7,000,000. Stone & Webster, Real Estate Trust Bldg., Engrs.

Pa., Phila.—A. J. Sauer & Co., Archts., Dencla Bldg., is receiving bids for the construction of a 15 story, 38 x 104 ft. sales and office building, for the Cunningham Piano Co., 1312 Chestnut St. Estimated cost $2,000,000. Equipment detail not reported. Noted Nov. 14.

Pa., Phila.—K. E. Shapiro, 5850 Market St., plans the construction of a 4 story apartment house, on 63d and Jefferson Sts. Estimated cost $500,000. K. F. Otto, 3 North 19th St., Archt.

Pa., Phila.—H. Trumbauer, Archt., Land Title Bldg., is receiving bids for the construction of a 10 story 50 x 136 ft. social service building at 307 South Broad St. including steam heating system. Estimated cost $750,000. Owner's name withheld.

Pa., Reading—The Reading Coal & Iron Co., plans to completely electrify all its machinery breakers on properties in Northumberland and Schuykill Counties. Work will include construction of 5 or 6 large and modern power plants, operating as one system. Estimated cost will exceed $500,000.

Tex., Dawson—The city council will receive bids until Jan. 22, for steel tank and tower, c.i. pipe, hydrants, oil engine, pump etc. Estimated cost $45,000. Muuncipal Engr. Co., Praetorian Bldg., Dallas, Engrs.

Tex., Ft. Worth—The city voted $250,000 bonds for the construction of an electric lighting system. D. L. Lewis, City Engr.

Va., Richmond—The Hackley Morrison Co., Inc., 1708 Lewis St., is in the market for 150 hp. H.R.T. boiler, 150 lb. pressure, including stack, catalogue fittings and fixtures (quotations requested by wire from manufacturers), 125 hp. H.R.T. boiler, 40 hp. 100 lb. locomotive type boiler, belt conveyor, 12 ft. centers, 12 in. belt, portable conveyor 20 ft. centers, stiff leg derrick, 50 ft. boom, 2 ton capacity with bull wheel, 25 hp. D.D.D.C hoisting engine (used), 50 hp. Fairbanks, Morse type Y oil engine, a.c. electric hoist, 220 or 440 volt drum with boom swinger and two 10 ton 36 in. gauge locomotives.

W. Va., Wheeling—G. M. B. Sine, c/o Wheeling Ice & Coal Co., is in the market for ice making and cold storage equipment.

Wash., Kettlefalls—The White Pine Sash Co., Myrtle St. and Northern Pacific Tracks, Spokane, is having plans prepared for a complete band saw mill, electrically operated, including power plant, dam, etc., here. Estimated cost $150,000. F. W. Horstkoffe, Mohawk Bldg., Spokane, Engr. Sawmill machinery, engines, motors, boilers, etc. will be installed.

Wash., Walla Walla—The Burbank Irrigation Dist., is having preliminary plans prepared for the construction of a wing dam in the Snake River, here, for irrigation and hydro-electric development. Estimated cost $700,000. E. H. Chandler, Engr.

Wash., Walla Walla—The Tourist Hotel Assn., plans the construction of a 2 story hotel. Estimated cost $350,000.

Wis., Green Bay—The Bd. Educ., I. H. McIntire, Supt., is having plans prepared and will soon receive bids for the construction of a 3 story 120 x 400 ft. East High school. Estimated cost $500,000. Foeller, Schober & Stephenson, Nicollet Bldg., Archts. Equipment detail not reported.

Wis., Menasha—The John Strange Paper Co., Washington St., is in the market for 700 hp. in power boilers and 150 to 200 hp. in electric motors. Noted Dec. 19.

Wis., Milwaukee—N. J. Ropmeier, 531 M. & M. Bank Bldg., is in the market for ice making machinery.

Wis., North Bend—North Bend Co.-operative Creamery Co., J. Patterson, Pres., plans the construction of a 2 story creamery. Estimated cost $15,000. Architect not selected. Modern creamery machinery and steam power equipment will be installed.

Wis., Random Lake—The Krier Preserving Co., Belgium, is receiving bids for two 160 hp. water tube marine boilers with hand stokers and metal stack, one 125 hp. high pressure horizontal steam engine and one 125 hp. air compressor for proposed factory here. Private plans. Noted Dec. 12.

Wis., Sheboygan—J. & W. Jung Co., 720 North 8th St., is having plans prepared for the construction of a 50 x 100 ft. refrigerating plant and central heating station. Estimated cost $50,000. W. C. Weeks, 720 Ontario Ave., Archt. Refrigerating machinery and heating apparatus will be required.

Wis., Waunakee—A. P. Kenney, promoter, plans the construction of a 2 and 3 story cannery, consisting of main building, warehouse and power house. Estimated cost $100,000. Architect not selected. Canning machinery, conveyors, etc., will be required.

N. B., St. John—The Provincial Government will soon call for tenders for the development of Grand Falls, thence distribute electric power to all parts of the Province by high voltage transmission lines. The rights of the Grand Falls power, held by the International Paper Co., interests will expire in April, 1923.

Ont., Bowmanville—The Thomson Knitting Co., is in the market for electric motors and knitting machines for factory now under construction. Estimated cost $100,000.

Ont., Brantford—The city, F. P. Adams, City Engr., is in the market for 2 d.c. motor driven, centrifugal pumps, 15 hp., with necessary switchboard and controlling device.

Ont., Kincardine—The council, S. H. Scougall, Clk., plans the installation of an auxiliary gasoline, centrifugal, 3 stage fire pump, about 1,000 gal. per min. capacity and about 250 hp. engine. Noted Jan. 2.

Ont., Lansing—The Twp. of North York, H. D. Goode, Clk., plans the construction of storage dam and raped filtration plant, 12 in. c.i. water mains, steel stand pipe, pumphouse, hydrants and valves. Estimated total cost $125,000. James, Proctor & Redfern, 36 Toronto St., Toronto, Engrs. Tenders will soon be called for electric driven 3 stage centrifugal pumps. Noted Jan. 2.

Ont., Milton—The National Tractors Ltd., is taking over factory building and plans to install complete equipment for manufacture of tractors. Estimated cost $50,000. J. H. Haszler, c/o owner, Engr. Prices wanted on machinery and gasoline engines.

Ont., Mimico—The Hydro Electric Power Comn., University Ave., Toronto, will rebuild transformer station recently destroyed by fire on Church St. here, equipment will include transformers, switches, lighting arresters, oil switches, bus bars, etc. Estimated cost $25,000. F. A. Gaby, Hydro Bldg., Ch. Engr.

Ont., Rockland—The Rockland Electric Power System, A. C. Marion, Supt. is in the market for electric generators, motors, transformers, boilers, convertors, switchboards and wire. Estimated cost $25,000. Private plans.

Ont., Toronto—The Toronto Transportation Comn., H. H. Couzens, Gen. Mgr., 35 Yonge St., will receive bids until Jan. 18, for the construction of following buildings at Bathurst St. and Davenport Rd. (a) general repairs shops, comprising main building, boiler house and subsidiary buildings, including heating and ventilating, wiring, etc., (b) general stores building, including heating, ventilating, wiring, etc., estimated cost $1,500,000; also will receive bids until Jan. 17, for boiler house equipment for proposed general repair shops, including horizontal return tubular boilers, boiler settings, underfeed stokers, draft fans and boiler feed pumps. Private plans.

Ont., Whitby—The Canadian Wire Fence Co., plans the construction of a factory, estimated cost $25,000; motors, machinery and equipment will be installed, estimated cost $75,000.

CONTRACTS AWARDED

Calif., Bakersfield—The Bd. Supervisors, County of Kern, awarded the general contract for a group of hospital buildings, to W. G. Reed, 204 Brock Bldg., Long Beach, $427,000; heating and ventilating to F. Davidson, Washington Bldg., Los Angeles, $29,440. Noted Jan. 9.

Ill., Cahokia—The Union Elec. Light & Power Co., 12th and Locust Sts., St. Louis, Mo., awarded the contract for the construction of the first unit of power plant, or approximately one forth of the eventual plant which will measure 345 x 800 ft. and generate 320,000 hp., to McClellan & Junkersfeld, Inc., 45 William St., New York, equipment for first unit will embrace 2 steam turbo generator units, each 40,000 hp. capacity and 8 super-boilers to burn pulverized coal, cost of first section estimated at $8,500,000 with $1,500,000 additional for cables, conduits, transformers and switchboard apparatus for inter-connection with present system. Eventual plant will cost about $25,000,000 without inter-connections. Noted March 28, 1922.

Ill., Chicago—The First National Bank, of Chicago, 38 South Dearborn St., awarded the contract for the construction of a 21 story, 48 x 90 ft. addition to bank, on Monroe and Clark Sts., to the Leonard Constr. Co., 37 South Wabash Ave. Estimated cost $1,000,000. Steam heating system will be installed.

Mich., Detroit—The Public Lighting Comn., 138 East Atwater St., awarded the contract for an electric substation, including transformers and heating boiler and ventilating unit, to Corrick Bros., 507 Owen Bldg., $54,989. Noted Dec. 26.

Mich., Detroit—The Sacred Heart Seminary, 1219 Washington Blvd., awarded the contract for a group of buildings, including a 2 story, 64 x 147 ft. power house with stack, to W. E. Wood Co., 1805 Ford Bldg.; mechanical equipment, including 3 boilers, feed pumps, mechanical coal conveyors, stokers, ash handling equipment, incinerators etc. to be purchased by contractor. Noted Oct. 3.

N. J., Camden—The Bd. Educ., City Hall, awarded the contract for the construction of a 3 story, 149 x 282 ft. school on Park Blvd. and Euclid Ave., to the H. J. Homans & Co., 1701 Chestnut St., Phila. $465,750; heating and ventilating to J. H. Hutchinson, 1020 Callowhill St., Phila., Pa., $21,834. Noted Oct. 10.

N. Y., Freeport—The Bd. Educ., awarded the contract for the construction of a high school on Pine St., to the Moody Constr. Co., 90 West St., New York, $557,131. Equipment detail not reported. Noted Nov. 28, 1922.

N. Y., New York—H. A. Hyman, c/o Schwartz & Gross, Archts. and Engrs., 347 5th Ave., will build a 14 story, 95 x 150 ft, apartment building, by separate contracts, on 5th Ave. and 10th St. Estimated cost $2,000,000. Equipment detail not reported.

N. Y., New York—Schroeder & Koppe c/o Rouse & Goldstone, Archts. and Engrs., 512 5th Ave., will build by day labor, a 15 story, 82 x 110 ft. apartment building, at 157 East 72nd St. Estimated cost $850,000. Equipment detail not reported.

Ohio, Cleveland—The city awarded the contract for pump house, at the Lake Shore Blvd. pumping plant to D. Lowensohn, Davis & Farley Bldg., $25,918. Former contract rescinded. Noted Dec. 19.

Ohio, Columbus—The Franklin Constr. & Realty Co., 327 East State St., will build a 12 story, 84 x 125 ft. hotel on West Spring St. Estimated cost $1,000,000. E. E. Pruitt, Comstock Bldg., Archt. Equipment detail not reported.

Okla., Oklahoma City—The city awarded the contract for 3 marine type centrifugal pumping units, 3,450 gal. per min. capacity, to Rhinehart & Donavan, Tradesmans Nat. Bank Bldg., $27,520.

Ore., Portland—The State Bd. of Control awarded the general contract for three 1 and 2 story, 32 x 72, 42 x 150 and 60 x 176 ft. buildings for the Institute for the Blind to Rounds & Clist, Pittock Blk., $103,463; heating and plumbing to J. F. Shea, 4 North 2nd St., $29,800. Contract for power plant will be awarded later, no plans yet.

Pa., Corapolis—The Corapolis Ice Co., will build by day labor a 1½ story 32 x 60 ft. addition to plant on 4th and Kindell Sts. Equipment detail not reported.

Tex., Dallas—The Efficiency Apt. Corp., J. E. Kennefick, Pres., Great South Bldg., awarded the contract for the construction of an 11 story apartment hotel on Wolf and Maple Sts., to the Gilsonite Constr. Co., Great South Life Bldg. Estimated cost $1,250,000. Equipment detail not reported.

W. Va., Logan—The Kentucky & West Virginia Coal Co., awarded the contract for addition to power plant, increasing capacity from 25,000 kw. to 40,000 kw., including 125 mi. of lines from here to Hazard, Ky., to The Foundation Co., 120 Liberty St., New York. $800,000.

Wis., Milwaukee—The Wisconsin Ice & Coal Co., 216 West Water St., awarded the contract for a 1 story, 56 x 100 ft. addition to ice manufacturing plant, on East North Ave., to W. G. Williams, 352 Jackson St. Estimated cost $20,000. Additional refrigeration machinery will be installed.

Wis., Racine—The Racine Pure Milk Co., 1010 13th St., awarded the contract for the construction of a 26 x 46 ft. boiler house, to W. Fergus, 1119 Irving Pl. Estimated cost $10,000. Noted Dec. 12.